Vol. 1 OCTOBER, 1922 No. 10

JOURNAL

OF THE

AMERICAN WELDING SOCIETY

Published by the American Welding Society
33 West Thirty-ninth Street, New York

American Welding Society

OFFICERS FOR 1922-23

C. A. McCune, *President*
W. E. Symons, *Treasurer*
M. M. Kelly, *Acting Secretary*
Wm. Namack, *Vice-President*
T. F. Oechsle, *Vice-President*
W. A. Slack, *Vice-President*
W. Spraragen, *Editor, Journal*

DIRECTORS

Term expires 1923	*Term expires* 1924	*Term expires* 1925	*Section Representatives*
W. M. Beard	A. S. Kinney	James Burke	T. F. Barton
A. M. Candy	J. C. Lincoln	A. F. Jenkins	R. D. Malm
C. J. Holslag	H. L. Nicholson	Hermann Lemp	Wm. Namack
P. F. Willis	E. M. T. Ryder	H. I. Walsh	E. C. Sattley
	H. R. Swartley		
	E. Vom Steeg		
	E. Wanamaker		

PAST-PRESIDENTS

C. A. Adams (1919-20)
J. H. Deppeler (1920-21)
S. W. Miller (1921-22)

CHAIRMEN, STANDING COMMITTEES

Executive—C. A. McCune
Finance—W. E. Symons
By-Laws—Hermann Lemp
Meetings and Papers—A. G. Oehler
Membership—L. B. Mackenzie

American Bureau of Welding

(RESEARCH DEPARTMENT OF SOCIETY)

OFFICERS

C. A. Adams, *Director*
H. M. Hobart, *1st Vice-Director*
A. S. Kinney, *2nd Vice-Director*
Wm Spraragen, *Secretary*

CHAIRMEN, RESEARCH COMMITTEES

Electric Arc Welding—H. M. Hobart
Gas Welding—S. W. Miller
Welding of Storage Tanks—J. C. Lincoln
Pressure Vessels—H. L. Whittemore
Standard Tests for Welds—F. M. Farmer
Specifications for Steel to Be Welded—W. J. Beck
Welding Wire Specifications—C. A. McCune
Training of Operators—J. C. Wright
Resistance Welding—Hermann Lemp
Thermit Welding—J. H. Deppeler
Welded Rail Joint—G. K. Burgess

JOURNAL
OF THE
AMERICAN WELDING SOCIETY

Copyrighted 1922 by the American Welding Society,
33 West Thirty Ninth Street, New York.
Subscription $10.00 per year to United States. $11.00 to Canada. Libraries $5.00 Back numbers per copy, Members, $ .50; Non-Members, $1.00.
The Society is not responsible for any statement made or opinion expressed in its publications. Permission is given to reprint any article after its date of publication, provided proper credit is given.

Volume 1 October, 1922 Number 10

TABLE OF CONTENTS

Society and Related Activities

Fall Meeting of the Society 3
Pressure Vessel Program Launched 4
Secretary H. W. Cook Honored at Dinner 4
International Acetylene Association Convention 4
$20,000 Toward Cooperative Research 4
A. W. S. Directory 5
Regional Research 5
Section Activities 6
Employment Service Bulletin 8

Technical Papers, Items and Reports

Suitability of Materials for Welding Purposes 9
Gas Storage Tanks 25
Thermit Welding of Cast Iron 27
Cutting Manganese Steel 34
Recent Developments in Resistance Welding 38
Cast Welded Rail Joints 41
Resistance Bar-Weld Type of Rail Joint 42
Seam Welded Rail Joint 44
Books on Gas Welding of Cast Iron 46
Unfired Pressure Vessels 47
Current Welding Literature 53

Section Officers and Headquarters

PHILADELPHIA

Engineers' Club, 1317 Spruce Street, Philadelphia, Pa.
Chairman—Theo. F. Oechsle, Consulting Engineer, David Lupton's Sons Co.
Secretary—A. Schroeder, Standard Electric Welding Company.

CHICAGO

Peoples Gas Building, Chicago
Chairman—H. A. Austin, Mfg. Oxygen and Hydrogen.
Secretary—Harold W. Cook, Editor, Acetylene Journal Publishing Company.

PITTSBURGH

1841 Oliver Building, Pittsburgh
Chairman—J. D. Conway, Secretary-Treasurer, Railway Supply Manufacturers' Association.
Secretary—H. E. Hollis, P. O. Box 618, Pittsburgh, Pa.

NEW YORK

33 West Thirty-ninth Street, New York
Chairman—T. F. Barton, Master Mechanic, Delaware, Lackawanna & Western Railroad.
Secretary—A. E. Gaynor, J. A. Roebling's Sons Company.

NORTHERN NEW YORK

Niskayuna, N. Y.
Chairman—J. A. Seede, General Electric Company.
Secretary—D. H. Deyoe, General Electric Company.

CLEVELAND

Fourth Floor, Euclid Arcade Building, Cleveland.
Chairman—C. F. Eberhardt, President, Eberhardt Welding Company.
Secretary—Henry Spero, Brown Advertising Service.

SAN FRANCISCO

Rialto Building, San Francisco.
Chairman—H. L. Wintersgill, Westinghouse Electric and Mfg. Co.
Secretary—W. B. Sawyer, Jr., United States Steel Products Company.

LOS ANGELES

451 East Third Street, Los Angeles.
Chairman—L. J. Smith, District Sales Mgr., The Ideal Electric and Mfg. Co.
Secretary—E. W. Crane, E. E., Wilson Welder & Metals Company.

BOSTON

Engineers' Club, 2 Commonwealth Ave., Boston, Mass.
Chairman—Thomas A. Wry, General Electric Company, Lynn, Mass.
Secretary—J. W. Morrissey, P. F. McDonald & Co., Boston, Mass.

AMERICAN WELDING SOCIETY

ESTABLISHED 1919

JOURNAL

VOL. I. OCTOBER, 1922. NO. 10

FALL MEETING OF THE SOCIETY HELD IN CHICAGO

The fall meeting of the Society began with a meeting of the Committee on Specifications for Steel to be Welded on Monday afternoon, October 2nd, in the office of the Western Society of Engineers. Considerable progress was reported by this Committee on investigations to determine suitable qualities of steel for welding purposes. Several laboratories have cooperated in this important work. A report giving the results to date will be published shortly.

Tuesday morning was given over to an interesting session on cooperative research with the idea of establishing a regional or sectional plan for carrying out investigations. The plan as outlined received the enthusiastic support of those living within Chicago and vicinity. Mr. H. Cook, Editor, Acetylene Journal, and Secretary of the Chicago Section was appointed Chairman of the Organization Committee to handle details. The plan outlined at this meeting is described elsewhere in the Journal.

The technical sessions started Tuesday afternoon, October 3rd, at which time three very valuable papers were delivered on the welding of cast iron. These papers are a part of a symposium on this subject which has been prepared under the auspices of the American Bureau of Welding, setting forth the present state of the art of welding cast iron. General Properties of Cast Iron in so far as it affects its weldability was given consideration as well as actual details of gas, electric and thermit welding of cast iron. These papers are concluded in this issue. Discussion by members who can add to the information is particularly invited as it is the desire of the officers of the Bureau to bring the information up to date and make it as complete as possible. The help of every member of the Society is solicited.

The principle developments of the Executive Committee were a proposal that no returns be made the sections on Class D memberships. At the present time the Society retains only $2.50 for each Class D member which is a fraction of the annual expense to the national organization of each member for publication, mailing, etc. It was felt that such an adjustment would not work any hardship on the sections while it would be a "life saver" for the Society.

Several recommendations were proposed at this meeting for strengthening the Society financially. These proposals are being put in shape for presentation to the Board of Directors and the various sections and will undoubtedly be accepted. The cost of publication of the Journal was carefully scrutinzed So far the publication of the Journal has caused a deficit of $583.36 from the beginning of its publication in January to the October issue. This amount is not excessive as the deficit represents a difference between the actual cost and amount received for advertising and subscriptions. Beginning with the August-September issue the Journal will probably be self-supporting and it is only necessary that $200 more per month in advertising be secured to make it a source of revenue to the Society.

The members of the Committee on Training of Operators held an all day session on Wednesday, October 4th, and under the leadership of Mr. J. C. Wright, Chairman of the Committee and his assistant Mr. G. A. McGarvey, distinct progress was made. It is expected that the course on the Training of Operators will be completed very shortly, although a number of important details still remain to be solved.

One of the most important sessions of the annual fall meeting was that of the joint meeting with the American Electric Railway Engineering Association at the Municipal Pier, Wednesday afternoon, October 4th. Four very important papers were delivered and were well received, as well as a written dis-

cussion of same. This joint session marks a new era in the development of cooperation in solving the welding problems of today. The officers of the Society feel that great honor has been bestowed upon the American Welding Society at the recognition offered it at this joint session by the American Electric Railway Association.

The dinner held at the Hotel Morrison the same evening was also a distinct success. A number of nationally important people in the welding industry were in attendance. Most of the remarks made by the speakers were to the point and well taken. Even the musical talent were unusually demonstrative in their sympathies for the welding movement or at least the people connected with it.

The fall meeting closed with the meeting of the Committee on Welded Rail Joints at the Municipal Pier. The meeting was well attended and a number of important points in connection with the testing of samples were taken up at this time. Financial assistance is assured and every effort will be taken to have the test joints made before cold weather sets in.

PRESSURE VESSEL RESEARCH PROGRAM LAUNCHED

In the last issue of the Journal there was outlined a plan of activities undertaken by the Pressure Vessel Committee to determine the adequacy of the hydrostatic and hammer tests proposed for the testing of welded pressure vessels. Since that time the program has been amplified to include additional tanks purposely welded improperly in order to demonstrate if possible the fact that poor welding will be shown up by a proper test of the nature described. A number of tanks called for in the program have been built and the funds necessary for the testing have been supplied. This serves as another example of how manufacturers can get together cooperatively in research investigations.

SECRETARY H. W. COOK HONORED AT DINNER

One of the striking points at the fall dinner of the Society in Chicago was the honor bestowed upon H. W. Cook, Secretary of the Chicago Section. In speaking of his work, President McCune stated that without question the loyal services and hard work of this one man was in a large measure responsible for the success of the annual fall meeting of the Society. No one can realize who has not had the experience, the enormous amount of work that is attached to arranging the details of such a program.

It should also be pointed out in this connection that to Mr. Cook is due a large amount of credit for the assistance he has rendered in the development of the cooperative spirit in the Chicago vicinity and the stimulation of the activities of that Section in general.

INTERNATIONAL ACETYLENE ASSOCIATION HOLDS CONVENTION IN CHICAGO

The annual convention of the International Acetylene Association will be held in Chicago on October 25, 26 and 27. A formal invitation has been issued to the American Welding Society to attend the convention and participate in the discussions and to present a paper at the convention. Getting together of organizations of this sort is conducive to a spirit of cooperation and friendliness, and results to the advantage of all.

$20,000 GIVEN TOWARDS COOPERATIVE RESEARCH

At a recent meeting of the A. E. R. E. A. it was voted to supply or raise the $20,000 needed in the investigations of the Welded Rail Joint Committee.

It is recognized by all that a cooperative method such as undertaken by this Committee is much more likely to solve the complicated problems involved in welded rail joints than by the individual companies undertaking the work themselves. The Committee, one of the eleven research committees of the American Bureau of Welding, is organized along the general lines recommended by the Division of Engineering, National Research Council. It consists of representatives from electric railway companies, American Welding Society, rail and equipment manufacturers and technical laboratories. Its aims are first to determine the present state of the art; second to improve upon existing practices by the aid of all obtainable knowledge of the subject; third, by carefully directed scientific tests and experiments to learn the one best way of making each type of welded rail joint.

Under the cooperative method, the

cost to any one company is an exceedingly small fraction of the savings which will result to that company. It is hoped that other industries will follow this example in getting together in solving the particular problems in their field. Numerous examples in various fields of engineering are now available where this cooperative method is working out successfully. The $20,000 contribution of the American Electric Railway Association marks a new epoch in the development of cooperative research in welding.

A. W. S. DIRECTORY

The Society contemplates publishing in the very near future a complete directory of its entire membership which will include the name, address and business connection of every member. The class of membership will also be shown There can be no question but that every one interested in welding should have their name on this official blue book which will really be a "Who's Who" of the Welding Industry. Inasmuch as the compilation of the data for this directory will begin very shortly prospective members are urged to send in their application without delay. Class D members who desire to be transferred to Class "C" membership should also notify the Secretary to that effect.

GET ACQUAINTED

Every out of town member when visiting New York, should pay a visit to National Headquarters of the Society. Make it a place where mail or messages will reach you or a meeting place for appointments. In other words, it is your headquarters and you should use it as such.

Our office is located in the Engineering Societies Building, a sixteen story modern structure, which is the home of the Engineering Societies of the Country. Every member either out of town or local should be sufficiently interested to also learn how the numerous details of the Society are taken care of.

Therefore, when in town, do not fail to make this visit as you will be afforded a hearty welcome.

PLAN FOR REGIONAL RESEARCH PRESENTED TO THE CHICAGO SECTION

Definition:

The regional method of research differs from the ordinary committee work in that the members all live within a given locality and at no great distance from a common meeting place. All the scientific, practical and engineering talent, research facilities, etc., needed in the work of the Committee are obtained locally.

Advantages:

The advantages claimed for this plan are briefly as follows:

(a) It permits the holding of regular, frequent meetings without unnecessary loss of time on the part of Committee members and expenditure of money.

(b) It permits sustained interest of members as the frequency of meetings and their regularity does not allow time for the members to forget what happened at the previous meeting. Useless repetition of discussion is largely eliminated.

(c) A particular investigation may be carried to a successful completion in a very short time.

(d) It promotes interest in research in a particular locality and renders financing of the costs of investigations much easier.

Example of Regional Method of Research

There was organized about a year ago, under the auspices of the Northern New York Section of the American Welding Society, a sub-committee on the Electric Arc Welding of Cast Iron. The members of the Committee consisted of representatives of the General Electric Company, American Locomotive Company, West Albany Shops New York Central Railroad, one or two foundries and Union College. Meetings of the Committee were held fairly regularly at intervals of two weeks. The concentration of efforts of this Committee on the one problem permitted progress to be made at a rate approximately four times as fast as could be expected from Committee work where the members live at great distances (assuming services of the members are voluntary.)

Plan of Operation

Having selected a specific problem for consideration a number of experts are

called together for a preliminary conference to draw up a suitable statement of the problem, its importance and probable value of its solution. Members of a Committee (living in the vicinity) are then selected representative of the interested industry or branch of the profession, and the related sciences, educational institutions and, if possible, technical societies and governmental bureaus. Procedure may then develop somewhat as follows:

(a) Preparation of a bibliography and critical summary of our present knowledge, including the gathering of all available experience. These summaries serve the two-fold purpose of giving a concise statement of the best existing information and enabling the Committee to draw up more intelligently a program of needed research to obtain data that are lacking.

(b) Consideration of the summary and laying out of specific tests, inquiries or experiments. Often standardization of nomenclature and of methods of testing is necessary before effective progress can be made with the actual research. (Improvement of nomenclature or of testing methods and apparatus is in some cases one of the most valuable results accomplished.) Care is taken to select the more urgent or promising features of the project for the first attack and not to attempt more than there is reasonable probability of handling.

(c) Assignment of definite portions of the program to appropriate laboratories, sub-committees, companies or individuals.

(d) Stimulation of research in this field as may be fitting, by individuals, governmental bureaus, corporations or universities. To this end a list of research subjects may be compiled and published.

Precautions

In some localities there is likely to be a strong corporation, which will tend to influence results in its favor. This can be guarded against by properly choosing members who have diversified interests. Another point which must be given consideration is the fact that much better progress can be made if the committee concentrate its attention on one definite problem. Spreading of interests generally results in lack of accomplishments.

Connection with American Bureau of Welding and American Welding Society

Regional committees on welding generally report to the Research Committee of the Bureau, under whose province the work would naturally come, for example, a subject on gas welding would come under the Gas Welding Committee of the Bureau. In this way definite connection is established between the regional work of the American Welding Society and National Research Council for which two organizations the American Bureau of Welding is acting as the Welding Research Department.

Members living in Chicago Section and who are interested and willing to help in this work are advised to get in touch with Secretary H. W. Cook of the Chicago Section. The aid of those having research talent and facilities for conducting research investigations is particularly solicited.

SECTION ACTIVITIES

Chicago

The first fall meeting of the Chicago Section was combined with the annual fall meeting of the Society and a session held on Tuesday evening, October 3rd in the office of the Western Society of Engineers. Mr. H. A. Austin, the new Chairman of the section presided. The details of the meeting are given elsewhere in the Journal.

Pittsburgh

Mr. E. R. Norris, Master Mechanic of the Pittsburgh Steel Company, Monessen, was scheduled to deliver a paper at the Pittsburgh Section on October 13th on the subject of "Welding as a Factor in Steel Plant Maintenance."

New York

The first fall meeting of the New York Section was held in the Engineering Societies Building on September 12th, at which time Mr. F. E. Rogers of the Air Reduction Sales Company presented a moving picture on the "Manufacture and Use of Welding and Cutting Gases.

Northern New York

Mr. B. C. Tracey, Chairman of the Membership Committee, reported that

the membership of the Northern New York section was 79 with prospects of obtaining 20 new members. Mr. W. H. Namack, Chairman of the Sub-Committee on Electric Arc Welding of Cast Iron of the Northern New York section presented a report of the Committee on this subject. This report was divided into two parts, the first dealing with a comprehensive description of the present state of the art of electric arc welding of cast iron; the second half dealing with the results of investigations conducted by the Committee to obtain certain information which was lacking. The paper was well received and discussed by a number of those present.

Mr. L. A. Hugemont discussed the possibility of softening hard castings and welds by means of sprinkling them with powdered copper and then bringing the casting up to a certain temperature in a furnace. He read a letter from the City Chemist of Zurich, Switzerland, on this subject which did not agree with the speaker's suggestion.

Professor F. P. McKibben of Union College expressed his surprise at the strength of the welds the Committee had obtained on cast iron and also at the extreme hardness of the weld. He felt that if it was possible in some way to weld so as to keep the athmosphere away from the weld, thereby cutting out the nitrogen, a soft weld could be more easily made.

Mr. A .White, American Locomotive Company, stated that the results obtained by the Committe showed that cast iron could be welded and that further research should be made to determine how good welds could always be secured.

Mr. D. B. Rushmore, General Electric Company, spoke of the possibility of using an electrolytic iron and also of the various phenomena that affected the welding of cast iron.

Mr. R. E. Wagner of Pittsfield described a problem he had met at Pittsfield in welding a large cast iron frame, trying first to weld without studding with little success and afterwards studding and making a satisfactory weld.

Mr. W. L. Warner explained in detail the charts used by the speaker, which gave considerable valuable data.

Mr. E. J. O'Connell described in detail a difficult welding problem that they had in Troy in welding a large cast iron water wheel which had holes worn clear through the blades. This wheel was welded by inserting steel plate patches, studding and then welding the patches to the wheel.

The next meeting will be held on October 17th at which time Mr. Jos. McAllister will read a paper on "Experiences with Arc Welding."

Cleveland

The Cleveland Section has decided to make application for membership in the Council of Affiliated Technical Societies of Cleveland. A number of the Sections of the Society have made simlar connections with other engineering societies and this plan of cooperation has resulted to the advantage of all concerned. It provides a central meeting place and certain publicity that could not otherwise be obtained.

President C. A. McCune delivered a brief address on "Welding Fundamentals." Mr. C. A. McCune described the four principal fundamentals as operator, technique, aparatus and material. President McCune also touched upon the progress made by the different research committees of the American Bureau of Welding.

Boston

The Boston Section are now using the Engineers Club of Boston as their mailing headquarters. A motion was passed at a meeting on September 29th to hold future meetings of the section on the third Friday of each month. Two papers were delivered at the meeting on the 29th, one of them by Malcolm Thomson on "Arc Welding Processes," and the other by Mr. Woofter of the Thomson Electric Welding Company on "Resistance Welding."

The next meeting of the Section will be held at Dr. Krebs', General Welding and Equipment Company, 74 Brookline Avenue, Boston. Dr. Krebs will present a paper, illustrated with practical demonstrations of the subject matter.

EMPLOYMENT SERVICE BULLETIN

To meet the demand of its members, the American Welding Society maintains an Employment Service Bulletin. This service is particularly needed in the present business readjustment. The bulletin is divided into two sections—POSITIONS VACANT and SERVICES AVAILABLE. No charge will be made either to the available engineer, foreman or welder, or to the organization seeking welding talent. The number of opportunities for employment of which the Society has knowledge does not at present equal the number of men whos services are available. The cooperation of members of the Society, industrial establishments and others needing the services of men trained in the various branches of welding is earnestly desired. The fact that an applicant for a particular position reads the Journal of the American Welding Society shows an honest effort on his part to keep abreast of the latest advancements in his chosen field. The location, necessary, qualifications for each position and the approximate salary, if possible, should be stated in each case.

Opportunities.—The Society is glad to learn of desirable opportunities from responsible sources, announcements of which will be published without charge in the bulletin.

Services Available.—Under this heading brief announcements (not more than seventy-five words in length) will be published without charge to members. Announcments will not be repeated except upon request received after an interval of three months; during this period, names and records will remain in the office reference files.

Note.—Copy for publication in the BULLETIN should reach the Society's Office not later than the Thirtieth of the month if publication in the following issue is desired. *ALL REPLIES should be Addressed to the Number Indicated in Each Case and Mailed to Society Headquarters.*

SERVICES AVAILABLE

A-12—Experienced electric welder desires position. Have had six years' experince in Locomotive shops at West Albany on locomotive work, including cast iron cylinders by means of the studding process, all kinds of fire box work, patches, flues and overhead welding.

A-13—Electric Welder desires position. Have had six years' practical welding experience on all classes of locomotive, boiler and bench work. Can weld plate vertical and overhead position and am capable of preparing my own welding work. Have received one year of teacher's training and am competent to train other welders.

A-14—Welder desires position. Have had seven years experience on welding and cutting and have also acted as demonstrator for an electric arc welding manufacturer for two years.

PROGRESS REPORT OF COMMITTEE ON SPECIFICATIONS FOR STEEL TO BE WELDED

In the welding industry, the need has long been felt for a more complete and accurate knowledge of the effects of the many variables which influence the success of a weld. A valuable contribution to our fund of information on this subject is found in a progress report of one of the Research Committees of the American Bureau of Welding given below. The authors of this paper have developed a method which they propose for testing the suitability of various materials for welding purposes. While this is only a progress report and further work will no doubt be done along the same line, it is thought that the welding industry may derive considerable benefit from knowledge of what has already been done.

The photographs included in the report gives striking evidence of the difference in behavior under fusion between various kinds of steel and iron. Those having a low carbon content such as commercially pure open hearth iron displayed remarkably smooth surface under fusion tests. Such iron fused sharply without gas evolution and sparking and flowed freely when molten. On the other hand, mild steel when tested showed a quite different result. The steel effervesced during heating and boiled and bubbled near the fusion point.

However, mild steel with a carbon content of 0.15 has been welded satisfactorily in the past. In fact, specimens have been produced in ordinary ship plate which broke outside the weld.

With these facts in mind two questions naturally arise—first, was the absence of boiling and sparking in the fusion tests recorded, due to the chemical composition or to the absence of occluded gases in the commercially pure iron? This question was not answered by the tests thus far made.

Second does the presence of boiling and sparking in such fusion tests necessarily indicate that the material in question cannot be satisfactorily welded? Experience would seem to answer this question in the negative.

Thus, although it is natural to assume that, other things being equal, the material that flows smoothly and quietly in such fusion tests is easier to weld, it is fairly obvious from experience that this is not absolutely essential to a weldable material.

It is therefore suggested that the committee next undertake such tests as will show the connection between the indications of these fusion tests and the results of the standard tests of welded joints made in the same materials.

The real need is for specifications which when satisfied will assure the success of the weld. Such specifications will of course include the necessary tests by which the specifications may be most readily checked. This is the task set before the Committee. This preliminary report is a step in the right direction.

C. A. ADAMS, *Director American Bureau of Welding*

FUSION TESTS TO DETERMINE THE SUITABILITY OF VARIOUS MATERIALS FOR WELDING PURPOSES*

**J. H. NEAD and R. L. KENYON

The rapid development of autogenous welding, both oxyactylene and electric, in the last few years has brought welding engineers to a realization of the desirability of some dependable test to determine the suitability of different materials both for welding rods and for material *to be welded.* Up to the present time, most investigators have confined their efforts to a study of welding rods and wire—assuming that almost any kind of material in the plate or other structural form could be successfully welded if the proper

* This work was done under the auspices of the American Bureau of Welding—Committee on Specifications for Steel to be Welded. On account of its value to the welding industry it is published here as a progress report.

** Chairman of sub-committee to develop methods of testing to determine suitability of material to be welded.

kind of welding rod was used. It is true that repair work calls for autogenous welding on a large variety of materials and the welder must do the best job he can on the material he is asked to weld. However, there are many cases where a choice of material *is* possible, as in the fabrication of machine parts or other articles and in such cases a knowledge of the relative weldability of various grades of iron and steel is of immense value. This knowledge can only be obtained by means of some dependable test.

Before such a test could be developed it was necessary to determine what constitutes a satisfactory material to be welded. It is generally agreed that a sound weld can only be obtained when the metal fuses evenly and quietly and without excessive sputtering and boiling. This means a material thoroughly degasified and low in gas forming elements. Freedom from slag or slag forming constituents is also essential. With this in mind, three different methods were tried which should indicate freedom from gas or gas forming constituents which cause trouble by bubbling and sputtering during welding.

The first method tried consisted in coating one and a half inch wide sixteen gauge strips of various materials with vitreous enamel. The enamel was baked on the strips by the passage of an electric current through them. This heated the strips quickly and uniformly to the proper temperature. The materials tested consisted of commercially pure iron made in a basic open hearth furnace, copper bearing open hearth iron, basic open hearth mild steel, charcoal iron, Bessemer steel and silicon steel. In all cases except the open hearth irons, the enamel contained bubbles and blisters. The iron samples produced a perfectly smooth enamel surface free from any such defects. This indicates a freedom from gas or gas forming constituents which is not true of the other materials.

With the idea of carrying this test still further, another set of one and a half inch wide, sixteen gauge strip samples of various materials was prepared. No enamel was applied to these strips but they were heated as before. The electric current was gradually increased until the strip was brought slowly to the melting point and finally fused in two. The behavior of the samples near the fusion temperature was found to be characteristic of the materials. The iron samples melted quietly and threw out very few sparks while other grades of material threw out a shower of sparks and left a very rough surface after fusion. Figure 1 shows a general view of the samples tested.

The following is a key to the letters in the photograph.

S—Commercially pure open hearth iron.

H—Mild open hearth steel.

E—Commercially pure open hearth iron.
(Enameling grade)

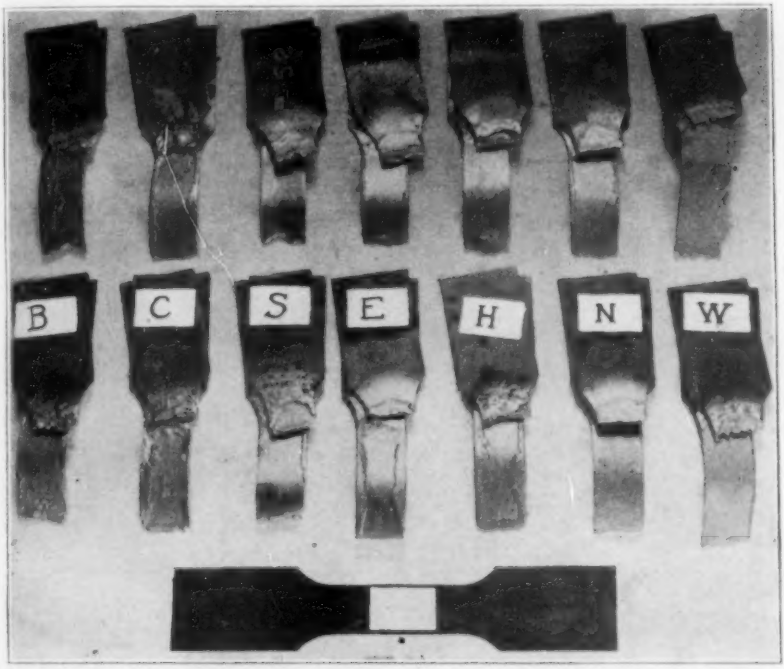


Fig. 1.

W—Silicon Steel.
N—Copper Bearing Open Hearth Iron.
B—Bessemer Steel.
C—Charcoal Iron.

The pictures of the various samples in Figures 2 and 3 are about three-fourth size. The two halves of the fused samples are placed one on top of the other and the roughness of the fused end of some of the samples is quite noticeable.

Contrast the smooth surface of the E and S samples with the rough blistered surface of H or B. This test checks the enameling test already described. In both cases the open hearth iron samples show freedom from gas or gas forming constituents. The metal fuses quietly and does not sputter, bubble, boil or throw out an excessive amount of sparks.

An oxyacetylene fusion test was next applied to sixteen gauge sheets of the same materials above described. The test is performed as follows:—A four inch square of the material is placed on a metal surface but blocked above it so that it doesn't touch. The surface is melted with a welding torch, moving it along just fast enough to melt the steel. An Oxweld torch with a No. 2 tip was used. Under this treatment suitable material should not "spit" or throw sparks, while in extreme cases of poor steel, the

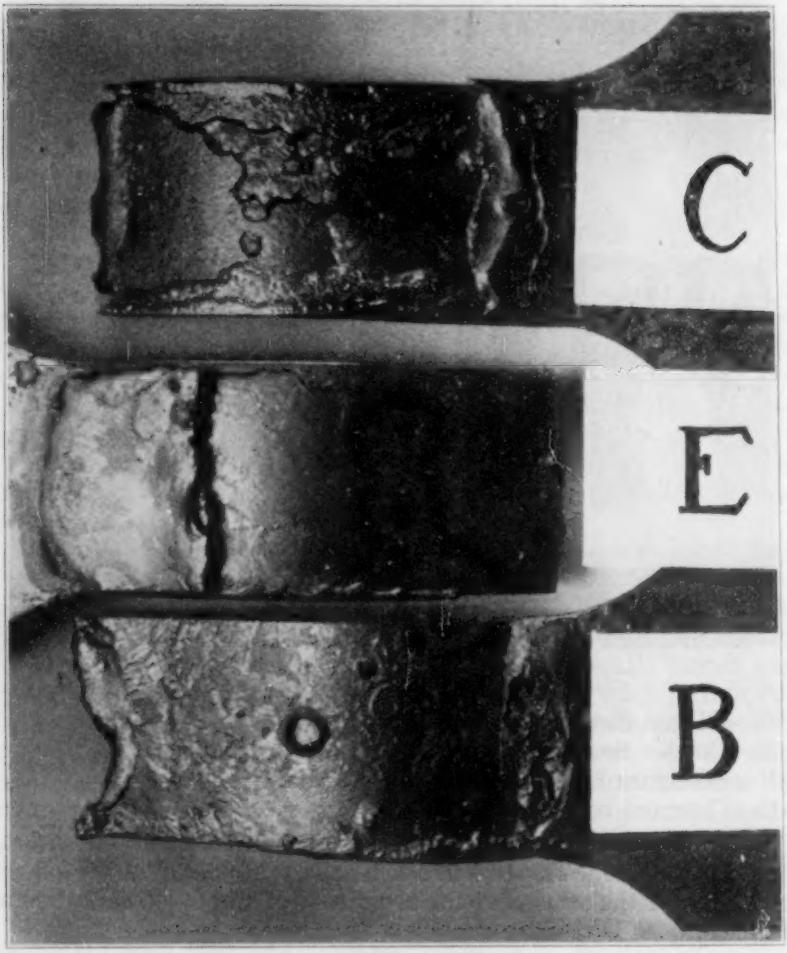


Fig. 2.

spitting may be so bad as to interrupt the flow of gases from the torch and cause it to backfire. Good material will show a smooth weld surface; poor steel will show a rougher matte surface. Good material unites well with the sides of the weld, bad steel leaves grooves (or ridges)) at the sides. Good material, when melted enough to partly drop through shows a clean smooth bead on the bottom, free from sponginess or porosity, while poor steel shows the bead rough and black and in extreme cases badly honey-combed. Poor steel will at times, as the melting progresses, have holes blown in it, even though there is no change in rate of welding or other conditions—good material will not do this and it is difficult to force a hole through a small melted pool with the torch flame. This

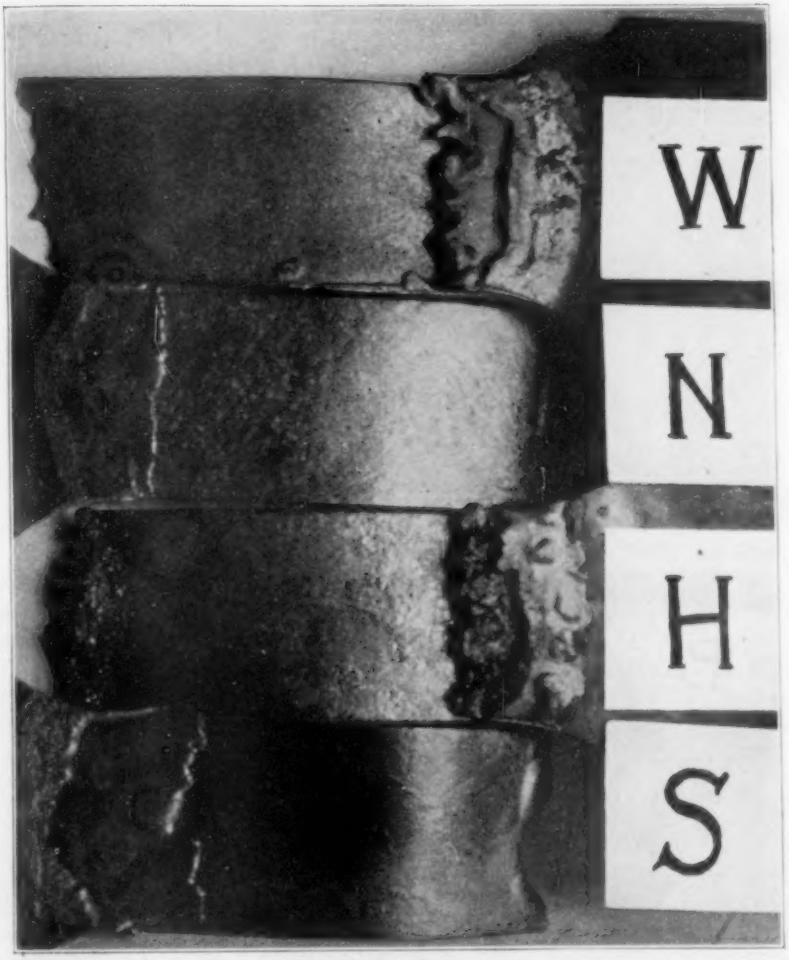


Fig. 3.

test is made by holding the torch tip vertically over the piece and leaving it there until a hole is blown through. This will occur quickly with poor steel but more slowly with good material. If the rounded surface at the edge of the hole is smooth and clean, the material is good, while a rough, black spongy appearance indicates poor steel.

Figures 4, 5, and 6 show the appearance of the top side of the samples after testing. The differences between the various samples are hard to show in a photograph reduced in size but are easily seen on the samples themselves. It will not be difficult, however, to see that there is a difference, for instance, between B, and E, in Fig. 5. In the B sample there is a row of small bubbles

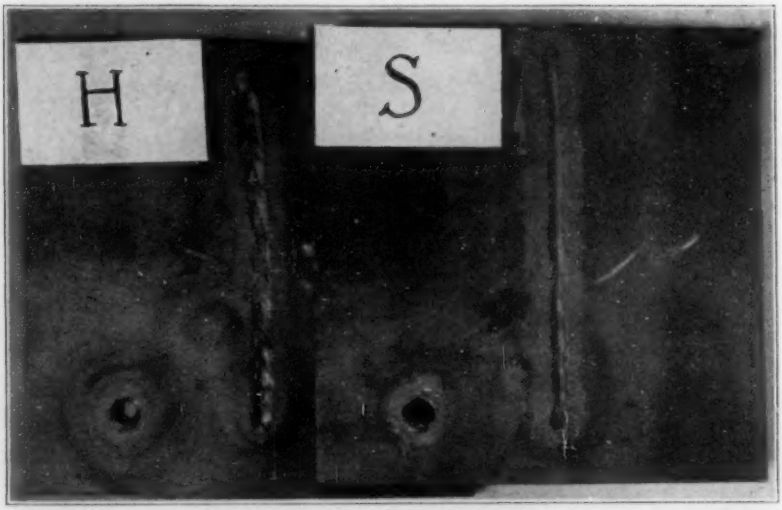


Fig. 4.

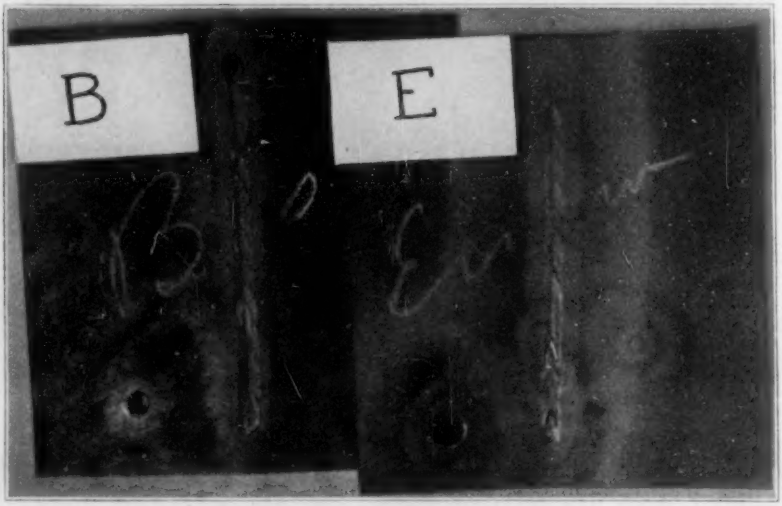


Fig. 5.

along the edge of the melted area and there is a porous spot at the lower end of the welding line. The edges of the blown hole are also porous. On the other hand the E sample has a very smooth surface and no bubbles. The blown hole is perfectly smooth. The H and S samples show a similar contrast. The S sample, commercially pure iron, is smooth and free from blisters or bubbles and the blown hole is smooth. This test then agrees with the other two tests in showing commercially pure basic open hearth iron to be free from gas or gas forming constituents.

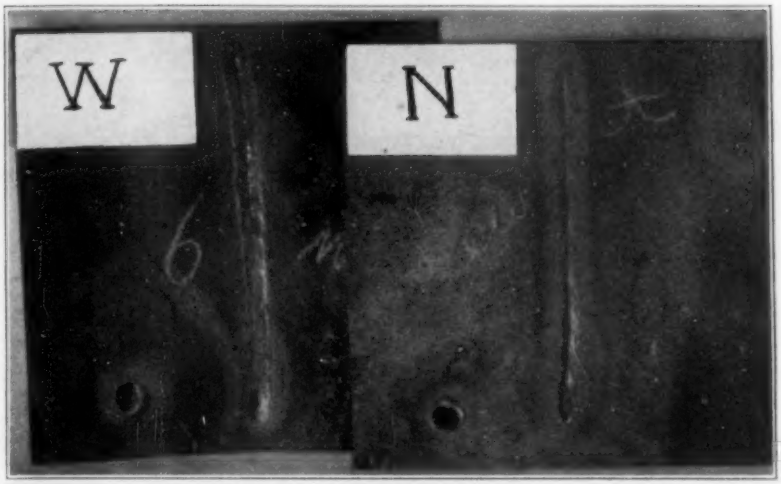


Fig. 6.

The electric fusion test and oxyacetylene fusion tests on sheets were so promising that it was decided to carry them out on a larger scale. For this purpose samples of ¼″ and ½″ plate were obtained. The materials tested were as follows:

Commercially pure open hearth iron.
.08—.12 Open hearth mild steel.
.10—.15 Open hearth steel.
.15—.25 Open hearth steel.
.25—.30 Open hearth steel.
"Boiler Plate."
Several tool steels.

Following out the previous experiments on the sixteen gauge sheets, the samples were cut from ¼″ and ½″ plate of various materials. An electric current was passed through the samples, heating them to fusion. On account of the large current required to fuse such heavy plate, arrangements were made with the Westinghouse Electric and Manufacturing Co., for performing the test in their plant at East Pittsburgh, Penna. Preliminary experiments conducted by Mr. O. H. Eschholz of that company led to the use of a butt-welding machine for performing the test. The materials used in the test were supplied by two different steel companies and were of commercial quality. They covered mainly, a range of straight carbon steels of carbon content from 0.30% down to practically zero in the case of commercially pure open hearth iron. The tests were made on both ¼″ and ½″ plates. The analysis of the materials tested is given in the following table.

The test pieces were cut 12″ long and 3″ wide and milled in the center from each side to a width of 1½″; parallel section 4″ long. The boiler plate samples, furnished by the Westinghouse Electric

SAMPLE NO.	MATERIAL	ANALYSIS				
		C	Mn	Sul	Phos	Cu
11	Mild Steel	.090	.394	.025	.015	.021
12	Commercially Pure Iron	.008	.009	.033	.007	.045
13	Mild Steel	.14	.41	.021	.017	
14	Mild Steel	.24	.42	.035	.014	
15	Mild Steel	.28	.44	.028	.017	
16	Mild Steel	.12	.350	.028	.016	.024
17	Commercially Pure Iron	.010	.016	.040	.010	.020
18	Mild Steel	.14	.42	.039	.016	
19	Mild Steel	.20	.47	.030	.013	
26	Machine Steel	.160	.475	.028	.014	.303
28	"Boiler Plate"	.260	.478	.038	.010	.153
29	"Boiler Plate"	.260	.478	.038	.010	.153
30	"Boiler Plate"	.140	.430	.042	.014	.063

and Manufacturing Co., were cut rough and not machined to exact dimensions.

The machine used in making these tests was a Thompson Butt-Welder No. 40-A-2 rated as 60 K. W. or 86 K. V. A It was wound for 220 volts at 60 cycles A. C. A special transformer stepped the voltage down from 220 to 4 volts. A regulator on the transformer provided a means of varying the current through the machine. The machine is capable of delivering 20,000 to 24,000 amperes. Fig. 7 shows the machine and control panels with a sample heated in the jaws. The switchboard for the machine is supplied with a voltmeter and ammeter in the primary circuit. For the purpose of this test, portable instruments were connected so as to give the voltage drop across the test piece and the current through it during test.

The vises of the machine were adjusted so as to tightly grip the test piece, the long dimension of which was horizontal and the flat surface in a vertical plane. (See Fig. 7) The current was turned on and held constant at a predetermined value. The voltage drop across the test piece was read at thirty second intervals and at the instant the current was broken by fusion of the sample. The test piece was observed through cobalt-blue glasses during the entire heating and fusing cycle and the appearance and behavior

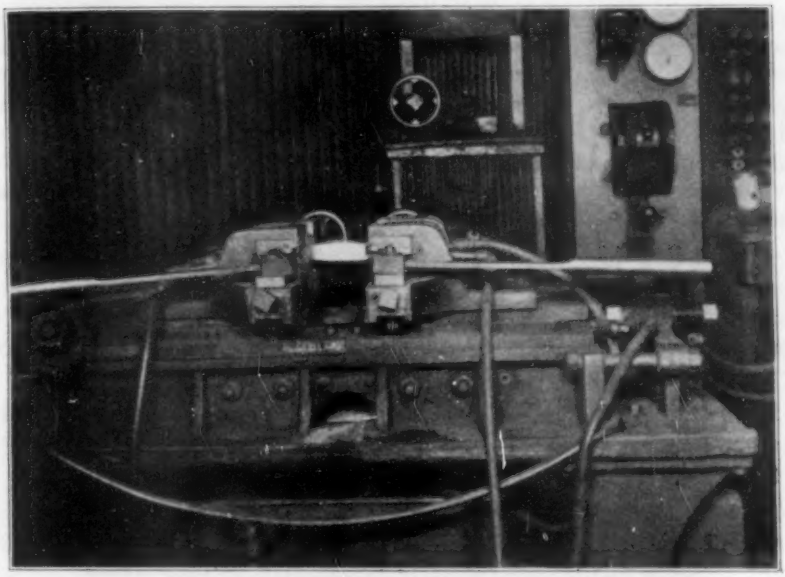


Fig. 7.

of the samples recorded. Since the current was kept constant the voltage drop across the test piece increased with the temprature, due to the increase in resistance of the sample.

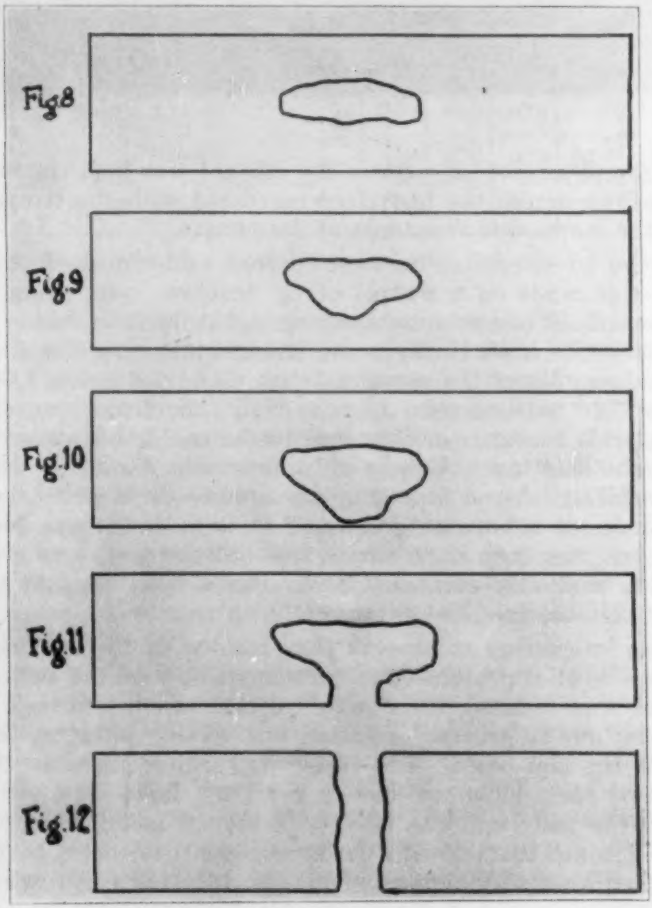
In order to determine the best current value to use in the test, a trial was made on a sample of ½" machine steel using 12,000 amperes. Only one minute was required to heat to fusion and it was difficult to observe the rapid changes near the fusion point. A second sample of the same material was tried using 8,000 amperes. This required two minutes and the phenomena of scale raising, scale fusion, sparkling and fusion could be watched better than in the first test. A piece of commercially pure iron was then tried and it was found that 8,000 amperes required about the same time for fusion of this material as of the machine steel. This current value was then used throughout all the tests made on ½" plate. In a similar manner 4,200 amperes was found by trial to be most suitable for the ¼" sample.

It was interesting to observe the progress of the fusion of the test piece as it approached the melting point. As the fusing temperature was reached, the central portion seemed to melt before the edges, due to greater radiation and cooling effect at the four edges of the test piece. The result was a hole fused in the side of the test piece, as shown in Fig. 8. This hole was not open through the plate but was filled with molten metal which seemed to be restrained from flowing out by surface tension. All the while the molten area was increasing in size, the rate of growth being

greater in a downward direction. (See Fig. 9) Finally the molten metal had insufficient support on the lower side and ran out. The lower half of the test piece fused almost simultaneously and the current per unit cross section in the remaining metal was increased so much that the top half fused very quickly. The progress of fusion has been analyzed into its successive stages but the whole sequence of phenomena just described occurred in just a few seconds. Figs. 10, 11, and 12 illustrate this progressive fusion.

Fig. 13 shows a sample of "boiler plate" just at the instant of fusion, with the metal running out and the sparks flying. This sparking was characteristic of all of the mild steels tested. The commercially pure open hearth iron was the only material free from this phenomenon.

A description of the behavior of the various samples in this test can best be made in connection with the photographs taken of



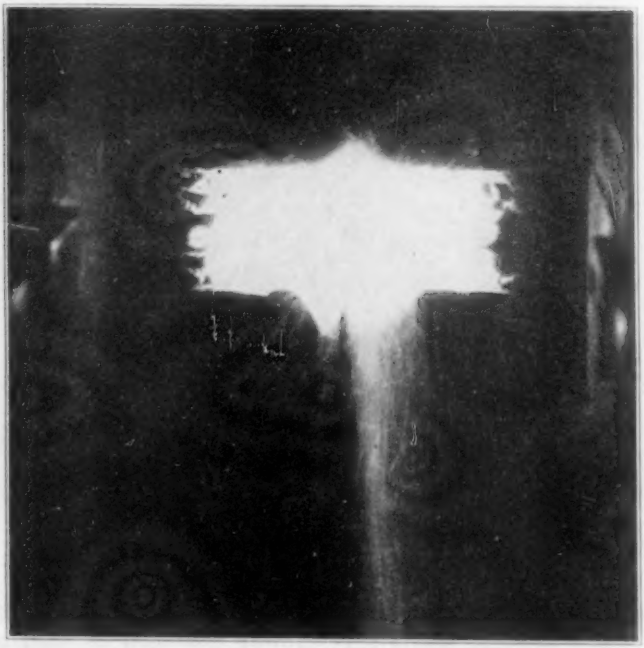


Fig. 13.

the specimens after testing. In Fig. 14, sample No. 11 is mild steel, and No. 12 is commercially pure open hearth iron. The difference between these two samples is striking. As has been said, the steel effervesced during heating, while the ingot iron fused quietly. The

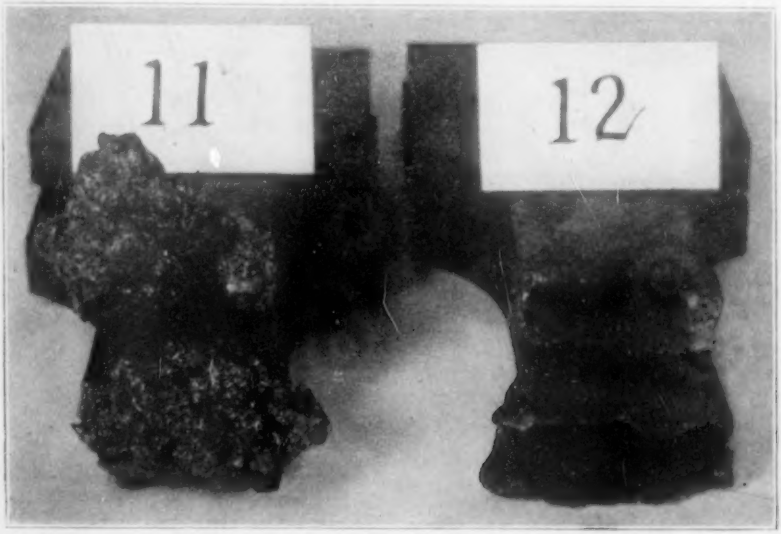


Fig. 14.

Fig. 15.

steel bubbled and boiled near the fusion point and the enlarged honey-combed ends of the fused sample are seen in this picture. The hollow center of the commercially pure iron is due to the cooling effect of the air on the surface of the sample, combined with the sharp melting point of the pure material. This picture in itself is evidence of the evolution of gas from the steel near its melting point and of the freedom of the commercially pure iron

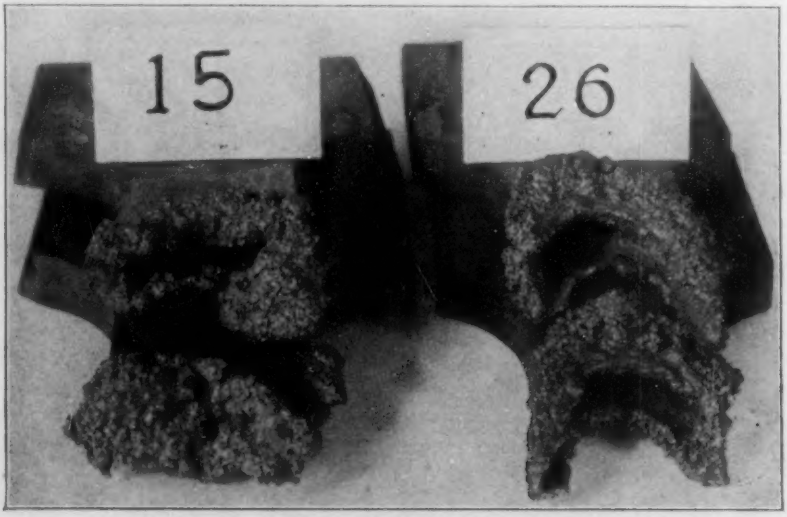


Fig. 16.

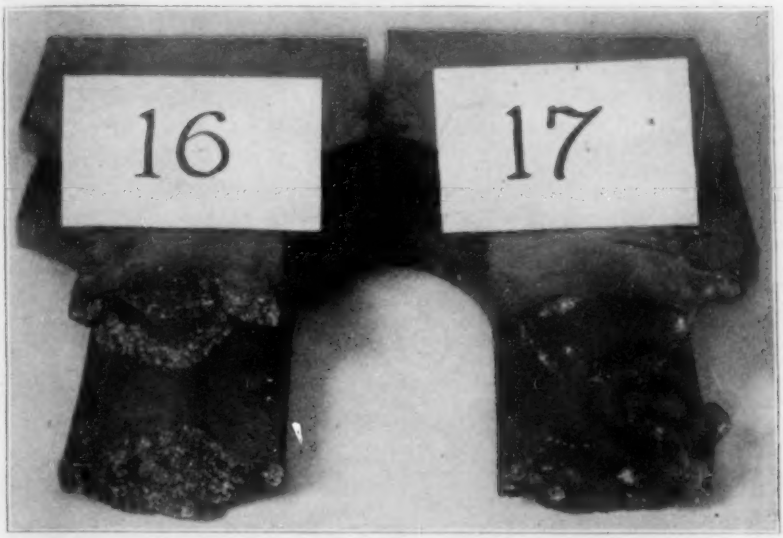


Fig. 17.

from gaseous or gas forming constituents. Further evidence of gas evolution in the case of ordinary steels is shown in Figs. 15 and 16. The analysis of these materials has already been given. Figs. 14, 15, and 16 all show tested samples of ½″ plate. The ¼″ plate samples showed similar differences between commercially pure iron and ordinary grades of steel. The appearance of four of the ¼″ samples is shown in Fig. 17 and 18. Sample No. 17 in Fig. 17 is commercially pure open hearth iron which is quite

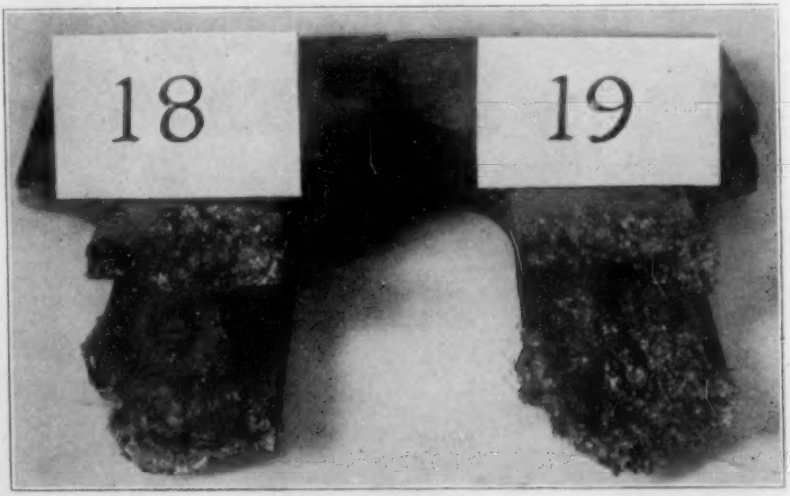


Fig. 18.

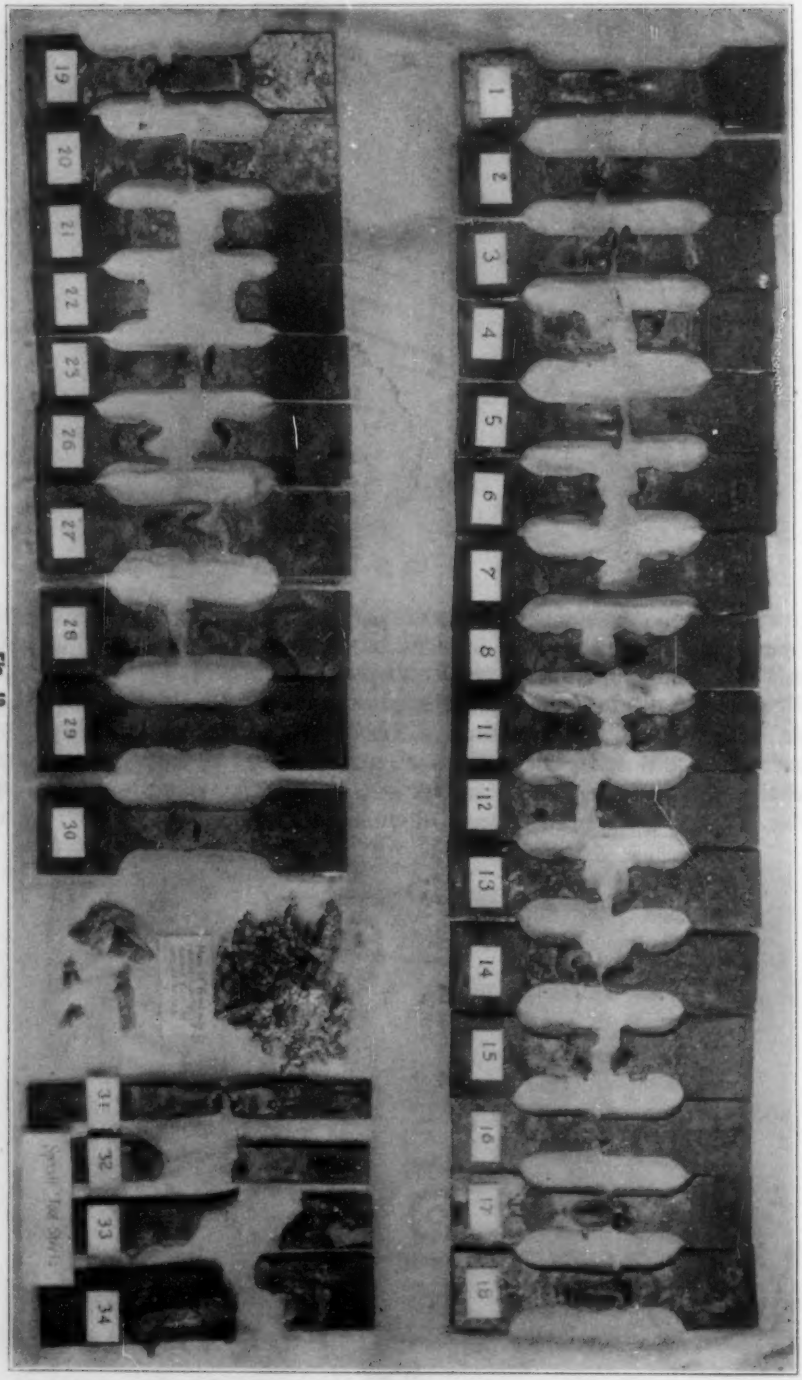

1
2
3
4
5
6
7
8
11
12
13
14
15
16
17
18
19
20
21
22
23
26
27
28
29
30
31
32
33
34

Fig. 19.

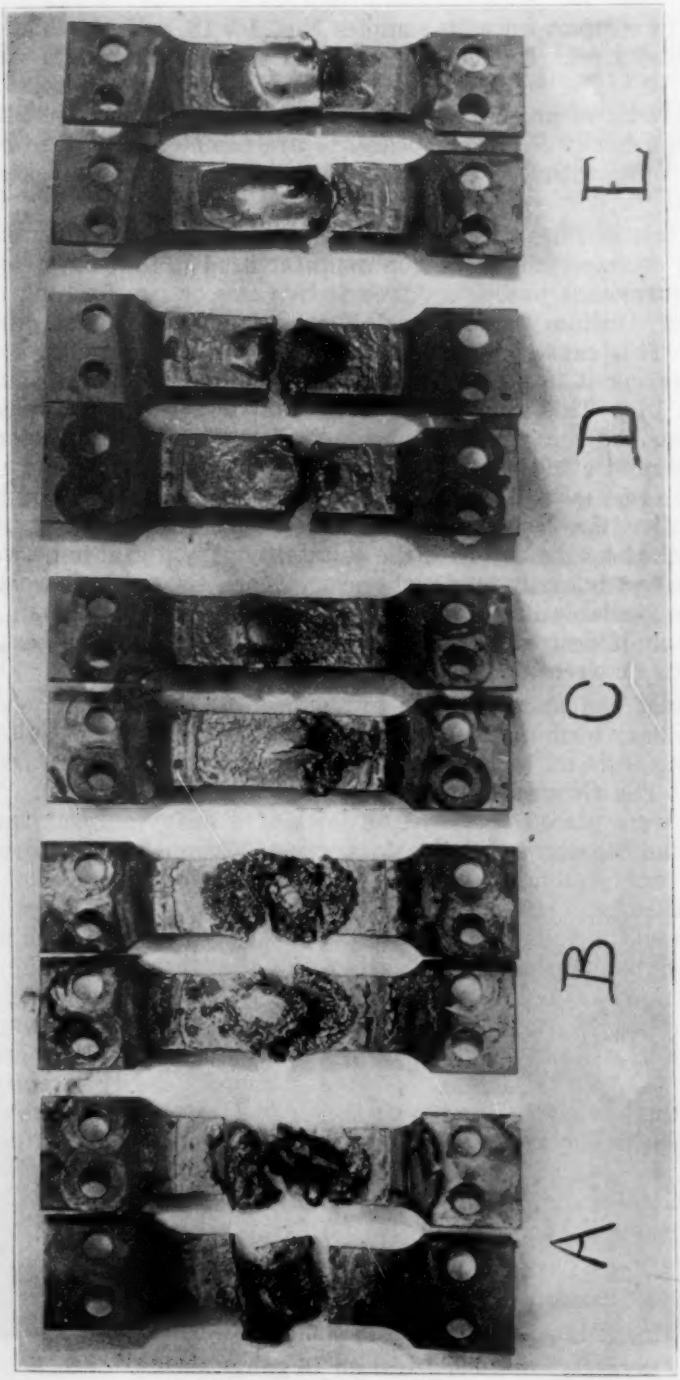


Fig. 20.

smooth in comparison with samples Nos. 16, 18, and 19 which are of ordinary steel. A general view of all of these samples is shown in Fig. 19. The rough fused ends on some of the samples are characteristic of ordinary steel. The samples which do not have this rough honey-combed appearance are commercially pure open hearth iron—with the exception of the tool steels so marked in the photograph.

This test confirms the previously described tests demonstrating that commercially pure iron manufactured in the basic open hearth furnace is practically free from gases or gas forming constituents. Ordinary steel gives off a large amount of gas during fusion. This causes blistering and bubbling of the metal, sometimes causing it to puff up to twice its original size. (See sample 11, Fig. 14) This gives us an additional test which shows why well degasified commercially pure open hearth iron is superior to ordinary mild steel both as a material for welding rods and as a material *to be welded.* Of the tests that have been described it is thought that this last one—the electric fusion test on heavy plate —gives the best indication of the suitability of material to be welded. The test is easily made wherever there is a butt-welding machine available and can be applied to samples cut from the work itself if desired. Half inch plate seems to give the best results with a current of 8,000 amperes on a 1½" wide strip.

This test can also be made by connecting the samples across the secondary terminals of a heavy current transformer of suitable size. The tests on ¼" material described above have been duplicated by The General Electric Company using this method. The samples were placed between the jaws of a heavy current transformer and the current at the start was 4500 amperes at 60 cycles. The current gradually dropped off, due to the resistance of the circuit, then gradually increased to about 3000 amperes, when the metal fused, opening the circuit. The time required in each case was about 2 minutes. This agrees in every detail with the results obtained in the butt-welding machine. The appearance of the samples after testing is shown in Fig. 20. The lettered samples are of the same materials as the following numbered samples in Fig. 19; A-18, B-19, C-20, D-16, E-17. The similiarity in appearance of the two sets of samples needs no comment. The fact that two different experimenters, working independently in different laboratories obtained practically identical results on duplicate sets of samples shows that this method of testing would give consistant results if adopted as a standard test.

SUMMARY: Three methods have been described for testing the suitability of material to be welded:

(A) Enameling test on 16 gauge sheets.

(B) Oxyacetylene fusion test on 16 gauge sheets.

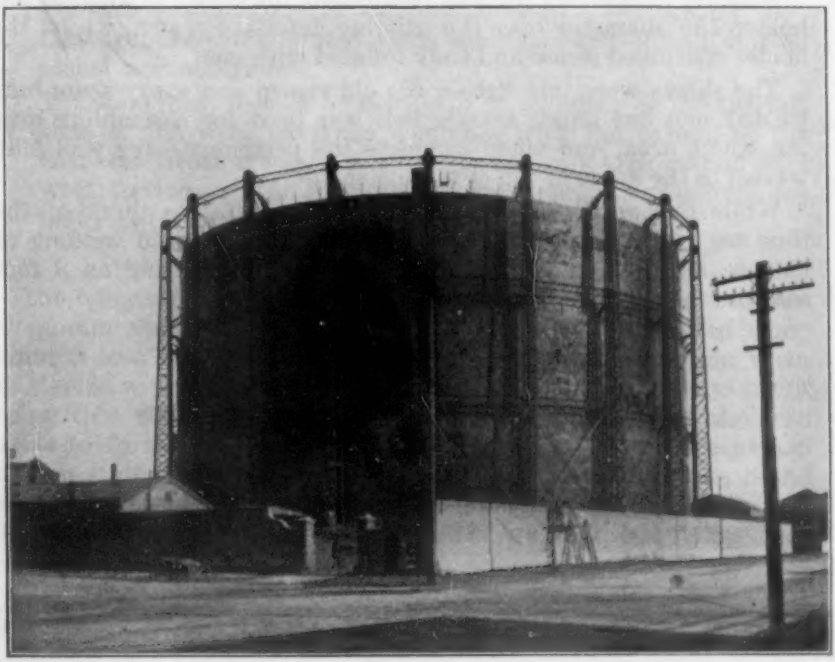
(C) Electric fusion test (on 16 gauge sheets.) (on ¼" and ½" plate.)

Of these three methods the last one was found to show the greatest difference between first class and inferior material to be welded. Commercially pure open hearth iron was the only material tested which showed freedom from gas or gas forming constituents when the metal was heated to a fusion temperature. It fused sharply and without gas evolution and sparking. It also flowed freely when molten. These qualities are desirable for autogeneous welding.

COMMUNICATION

Extracts From Letter Received From E. J. Rigby, Melbourne, Australia, Under Date of September 12th.

I am enclosing a photograph of a three million cubic feet Gas Holder which has lately been erected in Melbourne by the Metropolitan Gas Company. This was welded throughout by the Quasi-Arc process. The dimensions are 200 ft. diam., three telescopic lifts each 30 ft. high, height above street level well over 100 ft. The photograph below was taken the day it was first inflated. It went



up practically gas tight, only five or six pin holes showing in the whole envelope which weighs 600 tons and contains over 20 miles of lap welding in the sheets.

We met some little problems in welding various parts of this construction as you can imagine, but even so it cost no more than a rivetted one would have done and is an infinitely superior construction. The chief engineer of the Gas Company, Mr. Reeson, and his construction engineer and assistant, Mr. Groves, the present President of the Victorian Institute of Engineers, were responsible for the design and the work was all done in their own workships and they are so satisfied that they are now erecting a still larger holder with four telescopic lifts of 30 feet each. They now have a trained force of welders and the work is proceeding without a hitch.

I noticed at one of your meetings a list was published of various ships that had been welded throughout the world. Consider the size of this gas holder. As there is 30 feet of water in the bottom of it, it would just about find floating room inside for the whole fleet of them, including the U. S. Battle target, Admiralty barge and S. S. "Fullagar" with all their gear and flags flying.

I am not referring to this in greater detail because I understand it is to be the subject of a paper by Messrs. Reeson and Groves and will probably appear in London Engineer or Engineering.

Another interesting job was re-sheeting the crown of another gas holder 150′ diameter over the existing defective crown, whilst the holder continued in use and fully inflated with gas.

The sheets were laid flat on the old crown and every seam butt welded; not one single service bolt was used for assembling over the whole area, and when complete the periphery edge was fillet welded to the angle at top of the old shell.

While this work was going on I often smiled to think of the time we gave to the discussion of rigid and non-rigid welding of long seams in the old days when we were considering an 8 foot square tank.

WELDING CAST IRON BY MEANS OF THE THERMIT PROCESS*

J. H. DEPPELER†

Although Thermit welding finds a more frequent application in the welding of heavy steel parts, nevertheless this process is used very extensively for repairing broken cast iron sections of many kinds of equipment installed in railroad shops and other industrial plants. Some typical examples of cast iron welds are shown in the accompaning illustrations. (Figs. 1-5)

As is the case in welding wrought iron and steel so is the Thermit welding of cast iron particularly adapted to the repair of the heavier parts—not because the lighter parts cannot be Thermit welded—but because on this lighter work, the other processes requiring no mold construction are more economical and, in this lighter work ,the inherent ability of the Thermit weld to eliminate internal strains due to the fact that the weld is made all at one time is not so important.

The Thermit welding of cast iron follows practically the same procedure as in steel and wrought iron welding with the following differences:

1. The parts are preheated to only a dull red instead of to a bright red heat
2. Cast iron Thermit is used—this contains ferro-silicon, but no nickel nor manganese.
3. The weld must usually be machined by grinding as the thermit steel of the weld naturally combines with the carbon of the cast iron which it melts, forming a relatively high carbon steel weld, having greater strength and ductility than cast iron, but being harder.

What Thermit Is

The Thermit process is based on a chemical reaction between aluminum and iron oxide. Such a mixture can be ignited when brought to a high temperature in one spot and the reaction when so started will continue throughout the rest of the mass, the result being that the aluminum combines with the oxygen of the iron oxide to form aluminum oxide (or slag) in a highly superheated molten state while the iron is set free and is produced as liquid steel, also highly superheated. The temperature of this reaction is not measurable by any mechanical instrument, but it has been

†Chief Engineer, Metal & Thermit Corporation, New York.

* This report has been prepared under the auspices of the American Bureau of Welding and is part of a symposium on the welding of cast iron setting forth the "present state of the art."

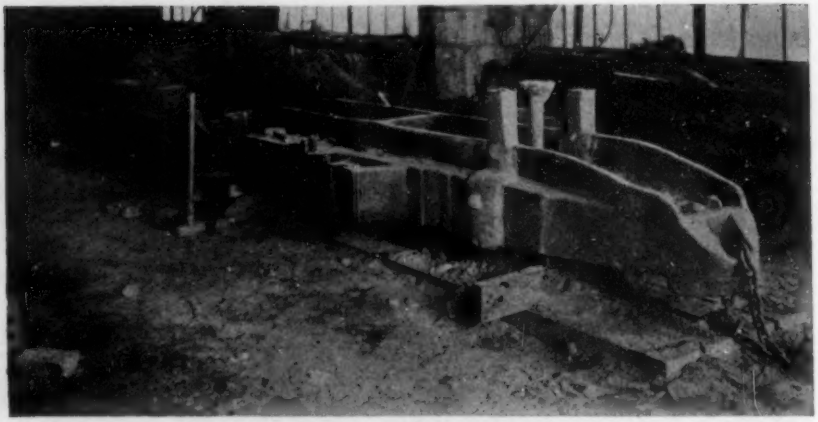


Fig. 1. Thermit weld in cast iron press frame

determined theoretically by metallurgists as approximately 5,000 degrees Fahr., or almost twice the temperature of ordinary liquid steel. It can readily be seen that if steel at this high temperature be poured around and between two iron sections, which have been previously preheated to a red heat, they will become dissolved and will amalgamate with the Thermit steel so that finally the entire mass will cool down to form a single homogeneous section.

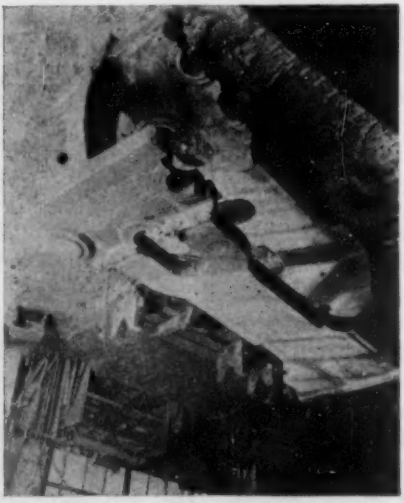


Fig. 2. Two Thermit welds made in cast iron frame of toggle press.

General Directions for Welding

In making Thermit welds, tram marks are placed on the two sections to gauge the allowance to be made for the contraction of the Thermit steel when it cools. The metal along the line of the

fracture is then cut out, either by means of an oxy-acetylene cutting flame or by drilling a series of holes along the line of the break; this provides an opening for a free flow of Thermit steel between the sections to be welded together. The sections are next cleaned thoroughly for a space of at least five inches. Allowance

Fig. 3. Two Thermit Welds in cast iron frame of press

for contraction is then made by setting the parts away from each other a sufficient amount to make up for the contraction of the thermit steel in cooling. This should vary from 3/16 in. to 5/16 in. depending upon the size of the weld and the length of time of preheat. In many cases it is necessary to obtain this increased space by forcing the sections apart with a jack or other mechanical means. In other cases where this mechanical expansion is prevented by an unbroken parallel member, for instance, the expansion is obtained by heating this unbroken parallel member by some convenient means.

The parts are now ready for the pattern which is made of yellow wax. This wax should be placed in a pan and warmed until it becomes plastic, or else melted entirely and then allowed to cool until it becomes plastic. This is shaped around the parts to be welded in the form of a collar as shown in Fig. 6. The opening between the ends should also be filled with wax and it is necessary to provide a vent hole through the wax extending from the location of the heating gate to the riser. The mold box should then be placed in position and securely blocked up so that all weight will be removed from the sections to be welded.

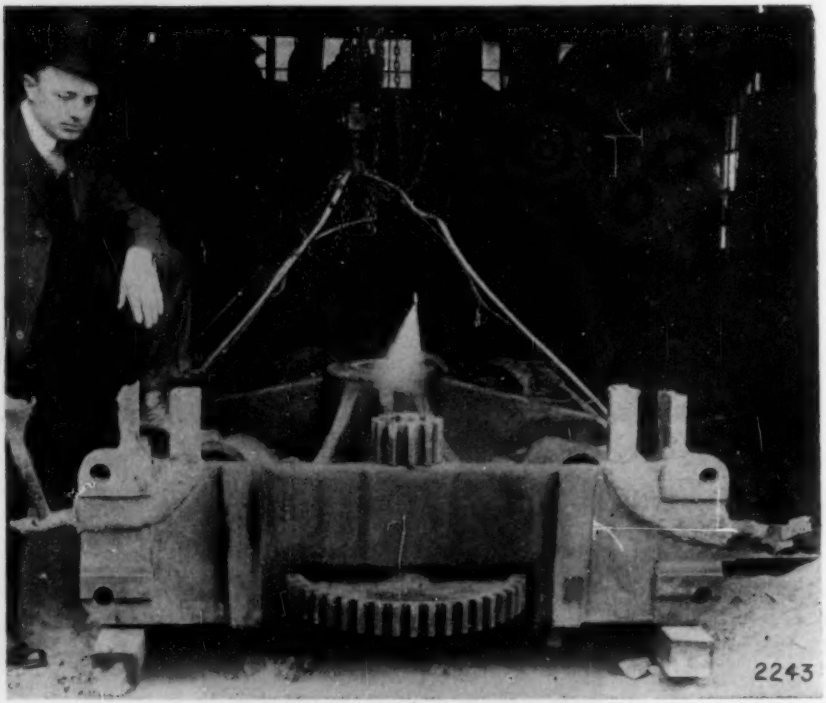


Fig. 4. Two Thermit Welds on cast iron base of crane.

We are now ready for the molding material. The selection of a proper molding material is probably one of the most important parts of the entire Thermit welding operations as upon this depends to a great extent, the soundness of the weld. After a great deal of research, the Metal & Thermit Corporation has developed a molding material, which exhibits both the necessary refractory qualities and the very necessary porosity after preheating. The first time a Thermit weld is made, such a molding material should be used throughout the mold. Thereafter, the molding material, once used, should be screened, sieved and re-used as backing in subsequent operations. New material should, however, always be used to face all portions of the mold with which the Thermit steel will come into contact, and it is usual to make this facing about one inch or so thick. The molding material should, of course, be moistened to its proper consistency to make it ram well. In ramming up the mold, a small amount of molding material should be placed in the box and rammed around the edges, working towards the center, keeping the molding material level and ramming hard. There should be a wall of molding material at least 4 inches thick between the wax pattern and the mold box at all points, as the

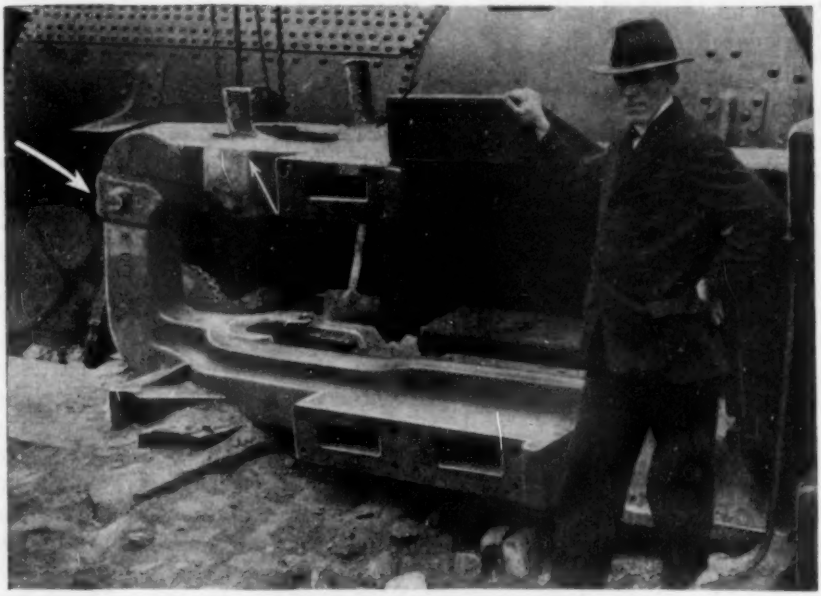


Fig. 5. Cast iron housing Thermit welded in three places.

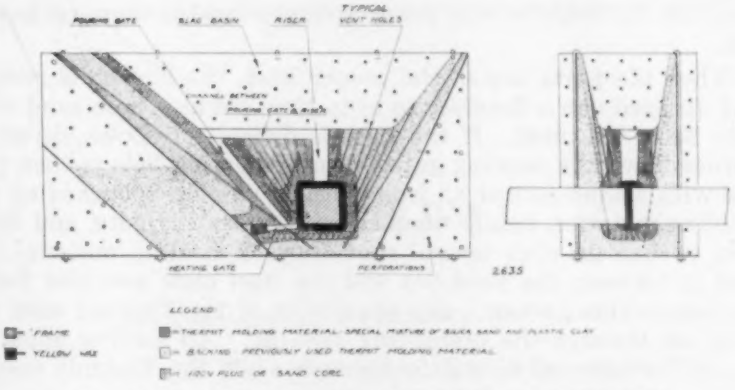


Fig. . Method of constructing molds for Thermit welds and materials needed.

Thermit steel is intensely hot and ample molding material should be provided to hold it.

A wooden gate pattern for the preheating opening should be set at the lowest point of the wax pattern and leading out to the front of the mold box where an opening is provided for it. A pouring gate pattern is placed with its lower end resting on the preheating gate pattern. A riser pattern is placed at the highest point of the

wax pattern. If there be more than one high point, a riser pattern is placed over each.

After the mold is all rammed, a basin is hollowed out on top in which the slag may collect so as not to over-run the mold box. A channel is cut in the top surface of the mold connecting the top of the pouring gate and the top of the riser. The mold is then vented thoroughly by forcing the vent rods down through the molding material to within three or four inches of the bottom. The function of the channel is to cause the first slag overflowing on the top of the mold to quickly run across to the riser and thus while the metal is still very liquid, equalize the pressure of the pouring gate and the riser.

When the mold has been rammed, the gate and riser patterns are withdrawn and the mold preheated by means of a kerosene and air blast. The burner should be set so as to point into the heating gate of the mold and about one inch from the opening. It is best to start easily at first as too much of the blast would tend to cut the mold. The wax will burn out leaving a perfect mold just the shape of the wax pattern. Keep the heat going until the mold is thoroughly dried out and the parts to be welded are brought up to a good heat. Steel pieces should be heated to a bright red heat, but care should be taken in preheating for cast iron welds not to heat sections too hot. A dull red is sufficient. One should be careful, however, to keep the heat going until the mold is thoroughly dried out.

When the parts are at the proper heat, the burner is removed and directed down the riser so as to blow out any loose sand which may be in the mold. If the riser is difficult of access, direct the burner down the pouring gate. The preheating hole is then plugged with a sand core or an iron plug. This plug is backed up with molding material, lightly tamped into the heating gate, and this in turn backed up with several shovelfuls of molding material rammed in between the mold box and the steel plate provided for the purpose. This prevents any possibility of the Thermit steel running out through the preheating opening. All heating apparatus should be removed to a safe distance while the Thermit reaction is in progress.

A small amount of ignition powder is now placed on top of the Thermit in the crucible and ignited (thermit will not ignite from the heat of the preheater and the reaction cannot be started without ignition powder). The crucible should be tapped when the reaction is over, which usually takes from 25 to 35 seconds. This is accomplished by knocking up the tapping pin which sets in the bottom of the crucible, using for the purpose, a tapping spade or a flat piece of iron.

The mold should be allowed to remain in place as long as pos-

sible, preferably over night, so as to anneal the metal in the weld, but in case of necessity, it can be removed after two or three hours in the case of the smaller Thermit welds. After removing the molds, the metal in the riser and pouring gate is cut off.

The Thermit used for welding cast iron is different than for wrought iron or steel and is known as Cast Iron Thermit. This consists of Plain Thermit with which is mixed 3% Ferro Silicon 50/50 and 20% mild steel punchings; i. e., to every 100 lbs. of Plain Thermit is added 3 lbs. of Ferro Silicon and 20 lbs. of punchings. This gives the best results on cast iron and produces a homogeneous metal in the weld.

Cast iron welds are naturally more difficult to machine than welds in wrought iron or steel, because cast iron contains over 3% carbon and when it fuses with the Thermit steel, the resulting metal at the weld is naturally a high carbon steel. The steel is considerably stronger and less brittle than cast iron, but is machined with difficulty. The finishing of cast iron welds is usually accomplished by grinding.

EMBLEM

All members of the Society are privileged to wear the Society emblem. Emblems may be obtained in two styles from the Secretary's office. Price, gold-filled, 75c., 14-K. gold, $5.00.

CUTTING MANGANESE STEEL

Z. T. DAVIS

The production of manganese steel casting presents a unique problem, because the metal is very hard on machine cutting tools. The castings can hardly be machined or cut except by means of the emery wheel or the oxy-acetylene flame, and at some point in their production nearly all manganese castings are subjected to oxy-acetylene cutting. In fact, one of the foremost manufacturers in the field acknowledges that without oxy-acetylene cutting his company would be unable to produce many of the types of castings which are now being manufactured or to maintain its present tonnage. This cutting, therefore, is a vital element in the production of manganese steel castings.

The chief utility of gas cutting is in the cleaning department, but it is used throughout the plant. The first application occurs immediately after the castings are taken from the sand, for removing gates and risers. Manganese steel castings are tempered by immersing them in water while the risers are still hot. On large castings risers are removed at red heat and a stay-bolt cutting blowpipe is used, because its length enables the operator to accomplish the cutting without undue exposure to the heat. Unless the casting is exceptionally large a medium-duty cutting blowpipe may be used for practically all riser cutting on the foundry floor. It is common practice to cut manganese steel risers a foot or more in diameter. Smaller castings, such as tractor treads, chain links and the like are sent directly from foundry to cleaning room, and the gates are removed where the other cutting involved in the process of cleaning is done.

The products of a large manganese steel foundry are so diversified that the cutting operators may be called upon to clean and trim castings weighing anywhere from a few ounces up to several tons each. Their work consists of removing fins, flashings and other imperfections, and correcting errors of casting. A common correction is the burning of a hole where the molder has omitted a core.

In the cleaning room the cutting blowpipe ceases to be a mere cutting-off or burning tool. The operators handle their torches with the dexterity of a sculptor wielding a chisel and mallet. With effectiveness and skill on large or small castings alike, they remove the gates, or risers, and then the surface imperfections. These may be very small, such as tiny fins, or the casting may carry considerable excess metal necessitating the cutting off of sections weighing

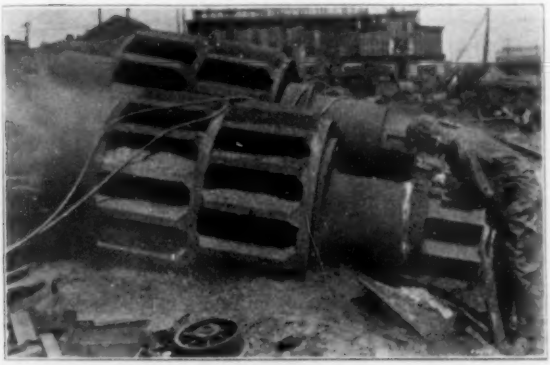


Fig. 1. Cutting Heavy Managanese Pinions in Scrap Yard.

Fig. 2. Removing Fins and Flashing from a Manganese Steel Switch Frog.

many pounds. The dexterity of oxy-acetylene operators and their familiarity with the castings (in some instances they work from a blue print) make it possible to practically complete the cleaning and preparation of the castings with no other tools than the cutting blowpipes. Of course, the castings are further surfaced and finished by grinding with power-driven emery wheels, but the real volume of work, once the metal has been cast, devolves upon the cleaning-room operators and their cutting blowpipes. They accomplish in seconds what an emery wheel would take hours to do.

Clam-shell buckets, steel mill machinery (including gears, rolls and other heavy parts) stone crushers, tractor treads, heavy chains, sand pumps, excavating and mining machinery, railroad cross-overs, switch frogs and other track sections and railway appliances form a superficial list of a manganese steel foundry's products, and give an idea of how varied castings are in form and size, and suggest how widespread is the application of oxy-acetylene cutting in a single stage of the manufacture of this kind of steel castings.

Fig. 3. Cutting off Risers and Trimming Manganese Steel Tractor Treads

Fig. 4. Cutting Manganese Steel Scraps into Charging Box Size.

The scrap yard, for a two-fold reason, is an important factor in the manganese steel business. Manganese scrap, is usable only at a manganese steel foundry, and, on account of its manganese content, it has considerable value as scrap.

The scrap consists of two kinds—(a) worn, broken and obsolete parts bought in the open market, and (b) the mis-runs and defective castings accumulated in the firm's own foundry. As the accompanying photographs indicate, the oxy-acetylene cutting blowpipe plays an important role at a manganese steel foundry, as it is the only mechanism available for effectively and economically reducing this scrap to a size adaptable for charging in the electric furnaces. Manganese steel castings are so tough that, in order to break them with a ball drop, it is necessary that they first be made more brittle by heating and air-cooling. Obviously reducing scrap by this method is an expensive procedure, as it involves considerable labor to handle large pieces of metal. Besides, there is the expense of heating.

Fig.. 5. Removing Fins from a half of a Manganese Steel Clam Shell Bucket.

Fig. 6. Large Manganese Steel Rolling Mill Pinion from which Sections have been cut.

The cutting blowpipe is supreme for the reduction of scrap. One company keeps two oxy-acetylene cutters on this work continuously and they have yet to encounter a manganese steel casting of size, shape or condition which could not be cut to charging box size.

Few branches of the metal industry are more dependent on oxy-acetylene cutting than is the manganese steel foundry. Before the perfection of the cutting blowpipe production of manganese steel castings was limited. The only feasible means of cleaning the castings was with the emery wheel. Consequently the cost of production was high, and the field was small. Since the cutting blowpipe has been adopted to the extent indicated above, the cost of manganese steel castings has been reduced and this has stimulated sales. Today manganese steel is used extensively in industries which make metal products that must withstand severe wear, and as a result, the use of oxy-acetylene cutting is being correspondingly extended.

SOME RECENT DEVELOPMENTS AND USES FOR RESISTANCE WELDING *

H. A. WOOFTER†

To the average man "Electric Welding" means Arc Welding. It will be a surprise to many to learn that resistance welding is more generally used in the manufacture of the articles we use every day, than all other methods of welding combined. Its use extends from the welding of the stems on the watches in our pockets, the frames of our eye glasses, the handles on our knives and forks, the rims and frames of our baby carriages, and our automobiles, rims for truck wheels, handles on wrenches, chisels and hay forks, shanks of mild steel onto high speed drills, reamers, and cutters,—chains for all purposes, and of all sizes—in fact, resistance welding is used either directly or indirectly in the manufacture of nearly every metal thing we use. The term "Resistance Welding" as used in this article, applies to seam welding, spot welding and butt welding, whether made by the Upset process, Flash process, or the new Contact Flash process. This latter process will be referred to again later.

Taking up the first classification, "Seam Welding", much development work has been carried on within the last two years. Until recently two sheets of No. 20 gauge stock was the maximum limit for flat commercial work, while two sheets of No. 18 gauge stock could be seamed by previously scarfing the edges. The limit in length of seam for this work was about two feet. Now, however, two ⅛" sheets have been welded on an experimental machine, and the length of seam can be practically anything that can be procured in commercial stock.

It is interesting to speculate upon the advantages offered by this advance in the art of seam welding. It can be applied to the manufacture of steel barrels, casks, tanks, culverts, smoke stacks, ventilators, conveyor tubes, heating and ventilating pipes etc. For example, if ⅛" steel barrel stock were rolled up and welded in 24 foot or 30 foot lengths, then cut up into barrel lengths, heads flanged and circular seams welded, the barrel would then be complete, with the exception of the bung collar, which would be a job for the arc or the acetylene welder.

The seams can be made at a rate of 40 feet per minute on two 1/16" sheets, and 20 feet per minute on two ⅛" sheets, without any scarfing, or special preparation of stock. Clean stock free from dirt, scale or rust should be used, for on any except clean stock the

†Electrical Engineer for Thomson Electric Welding Company and Thomson Spot Welder Company, Lynn, Mass.

*Paper read before American Welding Society, Boston Section, City Club, Boston, Mass., Sept. 29, 1922.

roller electrodes foul and pit, making it necessary to clean them between each weld. Also, on dirty stock, seams are irregular, burned through in places and not welded at all in others.

Taking up the second classification—"Spot Welding"—much experimenting and investigating has been carried on during the last two years. It is now definitely known that the mechanical pressures applied on the hot spot in the past, have not been sufficient to consummate a perfect spot weld. Furthermore, it is now known that as long as the matter of time, current and mechanical pressure applied is dependent on the human element—namely, the operator, the welds will lack uniformity, due to fatigue, inability to judge, inexperience etc. Accordingly, spot welders are now being designed that will be entirely automatic as regards, time and pressure, so that the welder will function in the same way each time, and make all welds alike. Some recent applications of spot welding are welding the outer edges of disc wheels for automobiles, reels for moving picture films, smoke stacks, ventilator pipes, and ventilator covers for ships, automobile bodies, motor cycle side car bodies, pressed steel automobile wheels and many forms of cooking and household utensils.

The third classification, "Butt Welding", may be sub-divided into three classes; namely, (1) Upset Welding, (2) Flash Welding and (3) Contact Flash Welding, or Automatic Butt Welding.

As regards the first subdivision, it is interesting to note that it is the oldest, or first process of electric welding to be used and was invented by Professor Elihu Thomson. It seems that the Upset welding process is being superseded for most purposes by the second classification, namely, Flash welding. The first is made by butting the cold ends of the stock to be welded, and then applying the electric pressure. The second is made by applying the electric pressure before the ends are in actual contact, and utilizing the flash or minute arcs that play between the ends of the stock. This arcing or flashing quickly heats up the adjacent ends to welding temperature, at which time the current is cut off and the ends quickly forced together to complete the weld.

Some advantages of Flash, over Upset welding are, less power required, less upseting or extrusion of stock, burned metal is thrown off in the flash, along with certain gasses, greater production (some Rim Manufacturers in Detroit are flash welding 300 automobile rims per hour constantly) and finally a stronger weld.

Some recent applications of Flash welding are welding auto truck wheels rolled up from I beams with a cross section 10″ wide by ⅝″ thick, train coupler links for England's railroads, drop forged hubs for disc wheels for Cadillac, Studebaker and Dodge cars, flyers for looms, steel welded wheels for Ford cars, Duralumin for a multiplicity of uses, and many others too numerous to mention.

The third subdivision, "Contact Flash Welding", is a new inven-

tion, soon to be placed on the market. It is in some respects very similar to Percussion welding, invented by Mr. Chubb of the Westinghouse Company, but is radically different in others.

The weld is made almost instantly. The nearby metal is not heated and a weld can be handled immediately after being removed from the welder without burning the hands. The Contact Flash process welds stock 1" diameter at present on an experimental welder, and it is expected to weld 1½" diameter stock or larger when a final model is built.

By some one of the Resistance welding processes, nearly all metals and alloys can now be welded. Tin is the notable exception. It can be welded, but the weld deteriorates so rapidly that it will fall apart the next day, due to what is called "Skin Disease". Lead, which was formerly very difficult to weld, can now be readily welded by the Contact Flash process. Stellite, which has been the cause of many disappointments and discouragements in the past, is now being successfully welded and is superseding high speed steel at a much lower cost. Brass is in a class by itself since the ease with which it can be welded varies with the coper and lead content of the particular sample being welded. Duralumin, when electrically welded, requires no annealing or treatment, and the weld is as strong as the original metal. Some grades of steel require annealing after welding to maintain normal strength. The cross section of stock that it is possible to weld by the Resistance process now seems to be limited only by the electric power available. Already, wires as small as electric light bulb filaments can be welded as a minimum, and from 16 to 20 square inches cross section as a maximum. However, welders could be built to weld practically any large cross section if Power Companies were able, and willing to supply unlimited power for welding purposes. This, however, they do not seem inclined to do at the present time throughout New England, but in Pennsylvania, Ohio, New York and many other states they are quite willing to cooperate with the manufacturer to the present maximum of power required for about 20 square inches cross section.

A special adaptation of the electric welder is seen in the electric pipe heater, which can also be used for heating rods or bars or billets; also the electric rivet heater, which will heat rivets of practicaly any size for practically all purposes. A still further adaptation of the electric resistance welding process is seen in the electric brazing machines and electric soldering machines which are extensively used in the manufacture of jewelry of all kinds, but especially in the brazing of hinges on to watch cases and devices on to gold rings, pins and badges. The electric soldering machine is extensively used in the manufacture of badges, breast pins, shoe buckles and various other low-priced products.

DISCUSSION OF PAPERS

CAST WELDED RAIL JOINTS*

G. L. WILSON†

At the meeting of the Committee on Welded Rail Joints on May 10th, 1922, at which there were present, 24 members representing principally different Electric Railways, there were presented statements and descriptions in regard to different types of welding rails by those with experience in each method.

The explanation of their practice and methods, also the reasons for continuing to use the different types was most interesting. It will be agreed by all present that each speaker was desirous of finding some improvement upon his present practice or a still better joint.

In general the desire appeared to be to perfect the technique and design of the particular joint described by each speaker. Each representative appeared to be desirous of obtaining the perfect joint, either by improvements on the methods employed by him or by a change to some other type, when such a type was proved to be the best.

Each company has a considerable equipment and has trained forces for the application of its present type of joint. Any new method will require new equipment and training of its men to apply another type of joint. While this may seem to be a small matter the joint problem is of so much importance that radical changes should not be adopted to the exclusion of the old until a new type has been proved to be fully satisfactory.

In the practice of the roads represented by the speakers, it was indicated that better results are being obtained through greater care in the application of the joints and in the grinding of the abutting rails to preserve smooth surfaces after the application of the joints to prevent cupping.

It appeared that all the methods under consideration were known to have some defect or difficulty. No one type or method is at present perfect and suitable for general application on all properties. Each representative believed that the technique of his especial joint could be improved and has some plans as to its betterment.

The investigation and testing of different types of joints by the Welded Rail Joint Committee, both in laboratories and in service will bring out the best points of each and enable that joint to be

*Discussion of Welded Rail Joints by Mr. E. M. T. Ryder. August-September issue Journal, A. W. S.

† G. L. Wilson, Way Engineer, Minneapolis Street Railways Co

selected which best suits practical conditions on different properties.

Until the results of such investigations are known, the writer believes that the cast welding or more properly the "Cast Grip" joint has given results on the Brooklyn, Milwaukee, Minneapolis & St. Paul properties which show such durability, economy, rapidity of application and generally satisfactory results that these companies are justified in continuing its use for their general construction while at the same time experimenting with other types to learn by actual service and the investigations of this committee, some other type if possible, which can be adopted in its place with entire confidence.

Experimental use of the different joints should be made by the larger companies to learn by actual practice the approved technique, advantages and disadvantages of each, under their own conditions. In this way by our own experience and the exchange of ideas, we shall develop a practice that will be the best for the properties we represent.

To speak more directly of the Cast Welding process in the Twin Cities I would state that taken into consideration the considerable length of time it has been almost exclusively employed, if there were serious failures and defective construction, it would be demonstrated by bad track conditions over a large amount of the trackage.

It has been a matter of satisfaction that men familiar with other types of joints and track construction elsewhere after personal inspection of track conditions in the Twin Cities, have almost unanimously advised the continuance of present practice.

The large proportion of joints welded in 1903 and subsequent years which still remain in perfect condition, indicate that the continued use of this process has been justified by its results as well as confirmed by the judgment of the experienced technical observers mentioned.

RESISTANCE BAR-WELD TYPE OF RAIL JOINT*

HOWARD H. GEORGE†

The Secretary of the American Bureau of Welding has asked me to discuss that part of Mr. Ryder's paper dealing with the Lorain bar-weld type of rail joint, and, in the limited time at my disposal, such discussion must necessarily be brief. I will, however,

* Discussion of "Welded Rail Joints" by Mr. E. M. T. Ryder, August-September issue Journal, A. W. S.

†Engineer Maintenance of Way, Public Service Railway Company, Newark, N. J.

endeavor to outline the main feature of the apparatus used and state the results of our experience with this joint extending over a period of over 19 years.

As many of you already know, the process consists of welding two bars against the web of the rail by the resistance method, one of the welds being made across the rail ends and the other two near the ends of the welding bars. The size of the bar depends on the rail section to be welded and the number and location of bolt and bond holes in the rail web. There are three separate steps in the operation; first, sand blasting rails and joint bars; second, the welding process itself; and, third, the grinding of the rail head to a true surface. I will not describe the sand blasting equipment, which is mounted on a single car.

The welding apparatus is carried on two cars coupled by special coupling arranged to allow sufficient movement to adjust the welder proper to all three welds, without moving the second car. It consists essentially of an alternating current transformer. The terminals of the secondary coil form the contacts or jaws, which clamp the bars against the rail and between which the weld is made. A hydraulic jack develops a pressure of about 4,000 lbs. per square inch on the rams of the jack, which pressure is increased by means of levers to about 37 tons pressure at the weld. The welder is so mounted as to be raised and lowered and swung from one rail to the other.

The welding transformer consists of a single turn of heavy copper on the secondary to 44 turns on the primary. The primary current is brought from the rotary converter in the car by means of flexible cables at about 300 volts A. C. The rear car contains an inverted rotary converter of 200 Kw. capacity for changing the direct current from the trolley to an alternating current. This passes through a Stillwell regulator, by means of which the primary current to the welding transformer is kept practically constant to within 25 volts regardless of the usual fluctuations on the line. The direct current voltage varies from about 350 to 550 volts and the converter takes about 350 amperes. The actual current used to effect the weld is from 25,000 to 30,000 amperes at about 7 volts.

The grinding apparatus is mounted on the fourth car, and consists of two grinding machines, one for each rail, the grinding wheels being carried on a carriage that slides back and forth on guides, so that the movement of the grinding wheels is independent of the character of the surface of the rail.

We have welded about 130,000 joints by this process since 1907 and we have, for some time, been using the head support type of bar, the chock being welded to the head at the same time the center weld is made. We attribute the present satisfactory results largely to this procedure. As in any other welded joint, it is essential

that the rails be carefully aligned and surfaced and that all space between the rail ends be closed by driving in shims of the required thickness cut from sections of the rail being welded, and finally it is necessary that the grinding be as carefully done as practical considerations will permit. The life of the joint depends very largely on the extent to which these precautions are observed.

It has been our experience that failure of these joints due to breakage of the bars is quite rare. Sometimes failures occur due to pulling apart of the bar from the rail web due to failure to accomplish a proper weld. The majority of the failures, however, are caused by the rail itself breaking just outside the outer weld. The fractures usually assume the same characteristic curve and this is probably due to a combination of internal stresses in the rail. This is a feature which should be made the subject of a scientific investigation in order to determine the actual causes responsible and what can be done to prevent this trouble. Considering the various conditions of old and new rail welded, however, the total annual breakage is not considered unreasonable. While the largest percentage of our joints have been installed on girder rail in paved track, we have also successfully welded a considerable number of joints in old tee rail in open track. In this case, it is essential that expansion provision be made in each rail for approximately every thousand feet of length in order to prevent track buckling when the rail expands. This expansion and contraction has a higher rate than in paved track as the entire rail is exposed and there is no paving to conduct a part of the heat to the subsoil or act as an insulator.

SEAM WELDED RAIL JOINTS*

W. W. WYSOR †

I have been asked to discuss Mr. Ryder's paper on Welded Rail Joints with especial reference to arc or seam welded joints. This is a hard subject to discuss in any authoritative way for the reason that we have no definite scientific data on the making of this type of joint, or the results obtained. This we do know, however, and that is that almost every engineer is proceeding according to his own ideas or a combination of his ideas and those of others who may have hit upon some more or less successful method. The word "hit" is used advisedly, for, in the development of this type of joint, we have had little information of a scientific nature to guide us.

Some research work of a laboratory nature has been done principally by manufacturing interests, and some tests have been made looking toward the determination of the strength of joints, these

* Discussion of "Welded Rail Joints", by Mr. E. M. T. Ryder, August-September issue Journal, A. W. S.

† Chief Engineer, United Railways & Electric Co., of Baltimore.

tests having been conducted both by Railway Companies and by Manufacturers, but little data of a conclusive nature is available, and so, as Mr. Ryder says, we are still floundering in the "Welded Rail Joint Woods".

It is to be hoped, however, that we are not hopelessly lost, and I, for one, believe that not only are we going to emerge from the woods, but that we will be all the better off for our sojourn there, although our bank accounts may have suffered somewhat in the meantime. Surely, there must be a compass available, maybe several of them, and through a rift in the tree tops, we can see a guiding star. This star is known as the Committee on Welded Rail Joints, which was formed by the American Bureau of Welding at the request of the American Electric Railway Engineering Association and is composed of representatives of the railway industry, manufacturers, Bureau of Standards, Universities and other Technical Societies. This Committee has formulated a program for the investigation of the Rail Welding Art, and the development of the various processes now in use to their highest degree of perfection.

This Committee proposes, under the direction of the American Electric Railway Engineering Association, to make laboratory tests of chemical, metallurgical and physical natures, and also to conduct a series of service tests on a machine especially constructed for the purpose under as near actual service conditions as possible. This service testing machine has been developed by the Way Committee of the Engineering Association, and it is believed that very important and conclusive information can be obtained in this manner, information that would not be obtained otherwise under five to ten years actual service in the track.

It is proposed that most of the tests, including those made on the service testing machine, shall be made by the Bureau of Standards at Washington, and the Bureau has very kindly consented to lend its services in this matter and to permit the erection of the service testing machine on its ground.

Speaking particularly of the Seam Welded Joint, some of the things which we need to know and about which engineers differ at the present time, are:

Design of joint plates, both with respect to cross section and length.

Use of base plates, and if answered in the affirmative, proper design of same.

Position of joint plates with respect to each other.

Length of seam welds and whether continuous or not.

Use of metallic or carbon arc.

Use of flux and its composition.

The pre-heating and post-heating of joints.

Composition of welding rods.

Use of shims.

Sand blasting of rail and plates before welding.

How we may make welds of sufficient cross-section and sufficient strength and ductility to stand up under repeated hammer blows of the wheels without cracking or failing in any other manner.

The solution of these and other questions, we believe, may be solved by the Committee and the Industry saved many times the cost of this research and testing work.

OXY-ACETYLENE WELDING OF CAST IRON

BIBLIOGRAPHY*

BOOKS

"Autogenous Welding" ..... *Grandjon & Rosemberg*
"Oxy-Acetylene Welding" ..... *S. W. Miller*
"The Welding Encyclopedia" ..... *The Welding Engineer*
"Oxy-Acetylene Welding Practice" ..... *Robert J. Kehl*
"Autogenous Welding & Cutting" ..... *Theodore Kautny*
"Gas Torch & Thermit Welding" ..... *Ethan Viall*
"Welding" ..... *Richard N. Hart*
"Oxy-Acetylene Welding & Cutting" ..... *P. F. Willis*
"Oxy-Acetylene Welding Manual" ..... *Lorn Campbell, Jr.*
"Automobile Welding with the O.A. Flame" ..... *Keith Dunham*

In the above are to be found full details of methods and practices used in welding cast iron, as well as other metals.

The New York Public Library has issued a complete bibliography of all articles published on welding in English, French and German up to 1915.

The files of the following publications contain valuable articles on welding cast iron:

"Machinery" ..... New York, N. Y.
"American Machinist" ..... New York, N. Y.
"Iron Age" ..... New York, N. Y.
"Iron Trade Review" ..... Cleveland, Ohio

The following publications are devoted entirely to welding and are most valuable, as the articles they contain are written from the welder's standpoint and give details that are sometimes absent in other publications. These articles are both practical and technical.

"Journal of the American Welding Society" .. New York, N. Y.
"The Welding Engineer" ..... Chicago, Ill.
"The Acetylene Journal" ..... Chicago, Ill.
"The Canadian Welding Journal" ..... Toronto, Canada.

* List compiled by Mr. S. W. Miller to supplement information on "Cast Iron Welding by the Oxy-acetylene Process" appearing in August-September issue Journal, A. W. S.

UNFIRED PRESSURE VESSELS

We are reprinting below an interesting paper on the above subject, which is to be presented before the International Acetlyene Association in Chicago on October 27th. Mr. Miller sets forth very clearly some of the facts in regard to the proposed code of the A. S. M. E.

It is a striking example of how an industry must get together to solve a common problem. Exponents of the gas and electric processes of welding should join hands for as Mr. Miller ably puts it the Boiler Code Committee has not made and will not make any differentiation between oxyacetylene and electric welding so that no matter how good a weld can be made by one process, the poorer of the two will control the code provisions. When the author illustrates this point by taking an assumed case of an oxyacetylene weld with a strength of 125% and an arc weld with a strength of 50% it is fairly obvious that he does not intend to imply that the oxy-acetylene welding is actually that much stronger than the arc weld. Moreover, there are many of those with experience in these two fields who would not be willing to admit any superiority of strength and quality of weld made by either process. Inasmuch as some of the tanks soon to be tested under the auspices of the American Bureau of Welding have been electrically welded and some of them gas welded, there will be some opportunity to check the accuracy of these opinions.

The American Bureau of Welding, welcomes the cooperation of any tank manufacturer who wishes to join in the work. The Bureau cannot, however, go to any further expense in making such solicitations.

UNFIRED PRESSURE VESSELS

S. W. MILLER

As in all other metal working processes, the development of fusion welding has been a gradual growth, and sometimes not in the right direction. That is, good design and construction, and safety, have at times been sacrificed in favor of cheapness, which has resulted in tremendous damage to the prestige of the industry. This has in some cases been done through ignorance, but I am afraid that in others it is in spite of knowledge of good methods. I do not mean that anyone has deliberately intended to make bad welds, but I know that practices that have resulted in failures have been continued after the failures have occurred, and after attention has been called to safe methods. It is therefore absolutely necessary for us, as an Association and individually, to refuse to countenance in any way methods which have proven unsafe, and to advocate in no uncertain manner, safe designs and methods.

One of the most important branches of industry is the manufacture of tanks for containing gases and liquids. Many of these are required to stand pressure in various amounts, and the majority of them are not heated by a fire as is a boiler. They are hence called unfired pressure vessels. They may be made of many materials, such as steel, copper, or brass, any one of which may be used in the cast or rolled condition. When cast, they are usually without joints, except such as are needed for piping or similar attachments.

When made of rolled material such as sheet or plate, they must

be seamless or else be joined in some manner, as by fusion, riveting, brazing, or forge welding.

Of these methods, all of which are in successful use, we are, as an Association, most directly interested in fusion welding by the oxyacetylene process. But we must not lose sight of the fact that we are vastly concerned in the success of all other methods. If a failure of any tank occurs, oxyacetylene welding is as likely to be blamed as any other method of joining, due to the frequent technical inaccuracies of published reports. We should therefore be zealous for good construction by all methods.

Oxyacetylene welded tanks, when properly designed and made, have the advantages of absolute tightness and perfect safety under all conditions. Tested to destruction, they will not rupture in the welds. Such tanks as have failed in service or under test have either been improperly designed, made of unsatisfactory material or poorly welded, usually the last.

The most severely tested tanks that I know of are described in a paper* read before the A. S. M. E.

It might seem that the results of these tests would be proof that it is entirely possible to make perfectly safe pressure vessels by the oxyacetylene process.

Before pursuing this angle of the subject further, let us go back and see the reasons for making these tests.

A number of years ago the A. S. M. E. appointed a committee of prominent engineers, manufacturers and others interested in steam boiler construction, to prepare a code for such boilers which would insure their safe construction. After many meetings and much discussion, a code was prepared, the first issue being in 1914. The difficulties met with were largely in the form of opposition from those who made boilers that were inherently unsafe, but which could be sold to those who bought on a price basis only. The code was revised and reissued in 1918, and is now undergoing another revision. It is essentially a safety code, and does not deal in any way with shop practice. It is the last word in such matters, and has been adopted as law in fourteen states and by many cities.

The code gives specifications for materials, formulas for the strength of the various parts of boilers, allows certain forms of construction, and prohibits others. The Code Committee meets monthly and considers questions raised by manufacturers, users, and others, as to matters covered by the code. Its official replies to questions are limited to statements as to whether proposed constructions or calculations comply with the code; in other words they only interpret the code. This is right. They cannot go further. But any important matters are considered, and when the code is revised any warranted changes are made.

---

* "Some Principals of Design of Unfired Pressure Vessels," by S. W. Miller. Presented at Atlanta meeting May, 1922.

The forces back of the code are that it provides that any boiler constructed in accordance with it may be stamped with the A. S. M. E. official code stamp, after an authorized inspector has certified to the fact, and that any boiler so stamped can be used in any state or city that has adopted the code as law.

The code does not and cannot prohibit the manufacture or use of any boiler, no matter how poorly it may be made. But the code stamp may not be applied to such boilers, and the law can, and does in many places, prohibit the use of any boiler unless it is made according to the code.

I have had the honor for several years of being associated with this committee in a minor capacity, though not as a member. I want to take this opportunity to testify to their ability, honesty and fair mindedness. They do not tolerate anything that to their minds appears unsafe, because they feel that their responsibility in the premises is very great. Yet they are always willing to consider carefully new ideas, and embody them in the code when it is shown that they are safe.

I have gone into some detail as to the Boiler Code Committee, its functions and operations, because of the bearing they have on the proposed pressure vessel code.

Some time ago the committee began to carry out the second part of the work for which they were originally appointed, that is, to prepare a code for unfired pressure vessels, similar to the boiler code. This code, in tentative form, has been published for public hearing twice. It has been again revised, and is published in "Mechanical Engineering" for November, still as a proposed code.

I want to impress on you, if possible, the necessity for a code and for only one code. The state and municipal inspectors have to contend with all kinds of workmanship in these pressure vessels. They have seen accidents, sometimes fatal, and frequently serious, from bad workmanship or design. The public is wondering what is being done to stop such accidents, the number and severity of which may be exaggerated, but which exaggeration affects the status of pressure vessels. The fact that a range boiler explodes and blows a house up cannot be explained to the public on the ground that it was improperly installed, but the impression is instantaneous that all range boilers may be dangerous, and their regulation is demanded.

Further, this demand is insistent, and if it is not met in one way it will be in another, because the constituted authorities will take action. It is impossible to foretell exactly what action 48 different states would take, but it is very sure that there would be differences in the different codes. Imagine the position of a tank manufacturer who had to make tanks to meet ten or fifteen or more codes!

It therefore is necessary that one and only one code be provided, and the only authority in this country that has prestige

enough to prepare one acceptable to the authorities is the Boiler Code Committee. They have prepared one, as stated above.

We will now consider the provisions of this code as they relate to welding, in which we have the greatest present interest. The code is concerned, in its present form, only with steel vessels, so we will confine the statements and arguments to them.

The committee, in its present frame of mind, has not made and will not make any differentiation between oxyacetylene and electric arc welding, so that no matter how good a weld can be made by one process, the poorer of the two will control the code provisions. That is, suppose we can make an oxyacetylene weld that has 125% of the plate strength, and that an arc welded vessel is only good for 50% of the plate strength, then oxyacetylene welding would be allowed only what arc welding will stand. But further, if either method could show no better than 50% efficiency, I am certainly of the opinion that no welding of longitudinal seams will be allowed at all, and the welding of circumferential seams would be very much restricted.

Please do not think that I am exaggerating, for I am not, as I shall now show.

In all the proposed codes, pressure vessels have been divided into classes, the ones most important to us being A and B.

Class A Vessels

Section U1 of the proposed code is:

Vessels for containing liquors above their boiling points at atmospheric pressure, inflammable substances, or any gas, and limited in size to those over 6 inches in diameter, more than 1.5 cu. ft. in volume, and carrying over 15 lbs. pressure per sq. in., except pressure vessels used in domestic water supply and those provided for in class C.

Class B

Vessels for containing liquids, the temperatures of which are under control so as to be below their boiling points at atmospheric pressure, and limited in size to those over 9 inches in diameter, more than 4 cu. ft. in volume, and carrying over 30 lbs. pressure per sq. in. but not to exceed 125 lbs. pressure per sq. in. For pressures over 125 lbs. per sq. in. the rules in Class A vessels apply.

Class C

Vessels for carrying on cooking or similar heating processes of food, medicinal or other chemical preparations, having surfaces coated with glass or similar enamel, and limited to a maximum working pressure of 150 lbs. per sq. in.

I quote further:

Paragraph U88. The following Class A vessels may be fabricated by means of autogenous welding, with the exception of

longitudinal seams, when the rules given in paragraphs U92 to U112 are followed:

a—Air tanks in which the pressure does not exceed 150 lbs. per sq. in.

b—Tanks for containing other than noxious or explosive gases (other than ammonia), when the pressure does not exceed 150 lbs. per sq. in.

c—Tanks for containing liquids other than those which are noxious or explosive, when the pressure does not exceed 150 lbs. per sq. in.

d—Tanks for containing ammonia shall be built for a maximum allowable working pressure of 250 lbs. per sq. in. and installed in connection with safety valves to prevent this pressure being exceeded.

Changing the wording of U88, we would be allowed to weld the heads or girth seams in any tank that contained air, gases that were not noxious, or non-explosive gases or liquids, but no welded longitudinal seams would be allowed, and 150 lbs. working pressure would be the limit.

Putting it another way, no welding at all could be done where the working pressure is over 150 lbs. per sq. in. (except in the case of ammonia, where 250 lbs, is allowed), and longitudinal seams are not permitted in any case.

Again, quoting paragraph U93

"When properly welded by the autogenous process, the strength of a joint may be taken as a maximum of 28,000 lbs. per sq. in. of net section of the plate."

You may say that there are inconsistencies and conflicting statements in the above, and I agree with you and would go further by saying that there are more in the parts of the code I have not quoted.

But mere inconsistencies can be and will be corrected, while fundamental restrictions may not be removed. Let us therefore forget the inconsistencies, and pay attention to the fundamentals.

The natural first question is, why such severe restrictions? And I answer you frankly, because of the accidents that have happened to welded tanks, and because of the neglect of the industry to show the Code Committee that such tanks can be safely welded and that a test can be employed that will always detect a poorly welded or unsafe tank.

I might very well refer to certain tests of welded tanks reported to the A. S. M. E. These tests were made for the purpose of giving the Code Committee information, and, though the tests showed that there was a method by which perfectly safe oxyacetylene welded pressure vessels could be made, yet we have today a proposed code containing such severe restrictions as practically to prohibit

welding of pressure vessels. And further, if such welding be prohibited, it will not be long before restrictions will be placed on other kinds of welding, because the obvious conclusion of the public will be that if tank welding be unsafe, all other welding must be dangerous.

I have spoken of the attitude of the State Inspectors, and it is no secret that no code can be made law unless they are convinced of its sanity, efficiency and safety. If you talk to them you will find, as I have, that they are reasonable and have a high sense of the duty they owe to the public. But they have not the time to study long reports and papers full of data and diagrams. In fact, actual observation and personal experience count more with them, as with the rest of us, than does any thing else.

Now as I see it, the point is this: if we do not believe that tanks can be safely welded, there is nothing for us to do but to do nothing. If we believe that the proposed restrictions are unfair to good welding, we must, to be honest with ourselves, the industry, the Code Committee and the public, do something. "Faith without works is dead."

Some of you will remember that at the annual meeting of the A. W. S. last April, a committee was appointed from the tank manufacturers and others present, to see if the industry as a whole or in part could be interested in getting by actual test, information on this subject for the Code Committee. Three hundred letters were sent to the manufacturers and others, and seven favorable replies were received. These seven agreed to contribute both tanks and funds to test them to destruction. Later several others were added to the list.

The idea is for each maker to weld the tanks as he pleases, using any materials he desires. They will all be of $\frac{3}{8}$" material, 24" dia., 6 ft. long in the shell, with dished heads concave to the pressure. They will be tested at the Bureau of Standards at Washington, using the methods decided on by the committee.

Another concern has agreed to furnish 23 other tanks. Three of these are of the above size, but will be purposely welded one fairly, one poorly and one badly. There will be 12, 4 each of $\frac{1}{8}$", 3-16" and $\frac{1}{4}$" thickness, one of each welded well, fairly, poorly and badly. These fifteen will be tested so as to bring out clearly the value of the hydrostatic hammer test. The other eight are 4 each of 3-16" and $\frac{1}{4}$" thickness, welded well, fairly, poorly and badly, and are placed at the disposal of the committee for such tests as they may decide on, either at their own initiative or at the suggestion of others.

It seems to me that, instead of there being only about sixty tanks to test, there should be several hundred, with corresponding funds. Those interested should settle, once for all in the minds of everyone, the questions at issue, the most important of which, in my judgment, is what test will always detect an unsafe vessel;

the other questions will be decided when that is solved.

The fundamental question is not whether we shall weld pressure vessels according to anyone's particular ideas, but whether we shall weld pressure vessels at all. And do not forget that steam lines, gas lines, oil lines and many other similar structures will sooner or later become involved in the discussion, unless we solve the problem now before us promptly and conclusively. The active and whole-hearted co-operation of everyone interested is necessary to such a solution.

CURRENT WELDING LITERATURE

TO OBTAIN COPIES OF PAPER—The Engineering Societies Library is prepared to supply copies, translations, or abstracts of any papers in the Library at the following rates

Translations, $5.00 per 1000 words and upward by arrangement.

Photoprint copies of articles, maps, etc., 25 cents per sheet, (11 by 14 in.): typewritten copies, $1 per 1000 words.

Bibliographic searching, abstracting, etc., $2 per hour.

Communications should be addressed to: The Engineering Societies Library, 29 West Thirty-ninth Street, New York.

Another Instance Where Welding Replaces Rivetting in Production Work, Acetylene Journal, (Oct. 1922), Vol. 24, pp. 180, 182. Illustrating possibility of increasing the application of the welding process to production.

Cutting and Welding of Castings, G. O. Carter, Iron Trade Review, (July 13, 1922), Vol. 71, pp. 107-10. Three Section Manifold, Regulator Troubles, Clean Metal Imperative, Divide Into Groups, Blowholes Cause Trouble, Cut Cost Lessened, Castings Warp, Avoid Cooling Strains, Gray Iron Practice, Used for Dismantling.

Electric Arc Welding in Coal Mining, E. Wanamaker, Coal Industry, Serial 1, (June, 1922), Vol. 5, pp. 276-9, Serial 11, (July, 1922), Vol. 5, pp. 321-3.

Electric Welding Theories, Practical Engineer, (July 6, 1922), Vol. 66, pp.5-6. Electrodes of the Future, Avoid Carbon, About Brittleness, The Harmful Elements.

Important Repair by Thermit Welding, Railway Journal, (Sept, 1922), Vol. 28, page 20.

Mechanical Control of Oxy-Acetylene Torch, Fred J. Maeurer, Canadian Machinery, (June 29, 1922), Vol. 27, pp. 27-28. Cutting Metal by this Process Approaches Very Closely the Maximum Theoretical Efficiency, Obtaining Any Desired Shape by Means of Templates, Application of the Radiograph.

Oxy-Acetylene Cutting and Welding in Foundry, G. O. Carter, Canadian Foundryman, (June, 1922), Vol. 13, pp. 36-9. Foundry, (July 1, 1922), Vol. 50, pp. 533-6. Installations of Equipment, Holding Work for Cutting, Operation of Cutting Process, Cutting Risers While Still Warm, Segregating Castings Into Sizes, Speed Not Dependent Entirely on Pressure, Cutting Through Blowholes in Risers, Effect of Cutting Metal, Welding Applications, Maintenance and Repair Work, Recapitulation.

Principles of Oxy-Acetylene Fusion Welding, Part Three—Welding Cast Iron, A. S. Kinsey, Railway Mechanical Engineer, (July, 1922), Vol. 96, pp. 416-8. Reasons for Ordinary Welding Practices.

Regular Smith Snop Tools Aid in Torch Welding, David Baxter, American Blacksmith, (July, 1922), Vol. 21, pp. 147-9.

Safe Practices in Oxy-Acetylene Welding, H. S. Smith, Acetylene Journal, (Oct. 1922), Vol. 4, pp. 184, 186, 188, 189, 199-202. Storage of Carbide and Gases, Installation of Equipment, Manifolding of Cylinders, Operation of Equipment, Importance of Wearing Goggles.

Tests of Structural Steel Welds, E. S. Humphreys, Jr., The Welding Engineer, (Sept. 1922), Vol. 7, pp, 23-25. How the reliability of welded joints is determined together with limiting conditions of various types of joints.

Thermit and Electric Welding, American Gas Journal, (July, 1922), Vo. 117, pp. 51-2. Dangers to be avoided.

The Scientific Side of Welding, E. A. Atkins, The Welding Engineer, (July, 1922), Vol. 7, pp. 32, 34-6, 38. Resistance Welds, Contact Welding, Spot Welding, Welding Wire for Iron and Steel. Material to be Welded.

The Soldering of Aluminum, J. A. Derby. The American Blacksmith, (July, 1922), Vol. 21, pp. 161-3. Solder only as last resort, A clear surface necessary, Tinning the work, Solders.

Use and Care of Regulators, Lorn Campbell, Jr., Welding Engineer, (Sept. 1922), Vol. 7, pp. 18-22. Importance of regulator action in securing proper welding flame, How minor repairs can be made in the shop.

Welding Repairs on Frog, C. J. Mackie, The Welding Engineer, (Sept, 1922), Vol. 7, pp. 17-18. Welding Shops Should be Conveniently Located, Records of Cost and Savings Should be Kept, Burlington Test Covering Three Years.

THE WELDING ENCYCLOPEDIA, SECOND EDITION (Book review copied from Welding Engineer)—Edited by L. B. Mackenzie and H. S. Card. A reference book on the theory, practice and application of the four autogenous welding processes. The first half of this book consists of a dictionary of all words, terms and trade names used in the welding industry. Included in this arrangement are instructions for welding operations on the most common types of repair work and production work, descriptions of the modern methods of testing welds, specifications for welding rods and wires for all classes of work, and descriptions of the application of welding to the various industries, such as automobile repairing, refrigerating machinery, structural steel, etc. Following the Dictionary Section are separate chapters on Oxy-Acetylene welding, Electric Arc welding, Electric Resistance welding and Thermit welding. Complete descriptions of each one of these processes are given followed by general operating instructions and special instructions for the application of each process to every metal which can be welded by it. Separate chapters are included on the subjects of boiler welding, tank welding, pipe welding and rail joint welding. Another section is devoted to the rules and regulations enforced by Federal and State authorities and insurance companies, on the construction, installation in operation of welding equipment, and on their application to various structures. A special chapter deals with the heat treatment of steel, one of the most important metals which the welder handles. A collection of charts and tables shows the variety of methods of preparing joints for welding, gives information on the characteristics of all the commoner metals, shows how to tell the temperature of metals by a color chart, and also show a color chart explaining the proper adjustment of the Oxy-Acetylene flame. The Catalogue Section at the end of the book describes and illustrates the standard lines of welding equipment and apparatus. 388 pages, 550 illustrations, flexible imitation leather, gilt edges, price $5.00

Members may obtain copies through the office of the American Welding Society, 33 West 39th Street, New York, at $3.00 each. No reduction in price will be made on orders received directly from the subscriber.

The American Welding Society

The American Welding Society is organized to provide united and co-operative action in extending the knowledge of the art of welding and its field of industrial application. The field for further application of welding is enormous, and progress in it is being delayed only by incomplete knowledge and by the confusing and opposing claims of competing interests.

The Society acts as a clearing house for information. Through papers and monthly meetings of local sections of the Society an opportunity is created for the individual manufacturer, engineer, plant superintendent, foreman, operator, etc., to contribute his own knowledge in welding and at the same time receive the benefit of the combined knowledge and experience of all other members of the Society. Special publications in addition to the regular monthly proceedings are issued from time to time giving results of researches, standardization work and other information of value to the members.

CLASSES OF MEMBERSHIP

Extracts From By-Laws

ARTICLE I

Section 1. Individuals having received the approval of a majority of the Membership Committee shall become members of this Society upon the payment of dues, except in the case of honorary members who shall be elected by unanimous vote of the full Board of Directors.

Section 2. Membership shall be divided into five classes:

Class A. Sustaining members, being individuals or individuals delegated by corporations, firms, partnerships, etc., interested in the science and art of welding, with full rights of membership. Annual dues $100.00

Class B. Members, being individuals interested in the science and art of welding, with full rights of membership.

Engineers or individuals competent by experience or training to plan or direct welding operations are eligible to this class. Annual dues $20.00

Class C. Associate members with right to vote but *not* to hold office, except in Sections as may be provided for by the By-Laws of the Sections. Supervising welders, inspectors and skilled operators, with three or more years' practical experience in welding are also eligible to this class. Annual dues $10.00

Class D. Operating members, who are welders or cutters by occupation, without the right to vote or hold office except in Sections as may be provided for by the By-Laws of the Sections. Annual dues $5.00

Write to the Secretary for a membership blank.

Technical Bulletins

These Bulletins are published under the auspices of the American Bureau of Welding. The Bureau is a joint advisory board of the American Welding Society and the Division of Engineering of the National Research Council on welding research and standardization. It acts as the Research Department of the Society.

BULLETIN No. I

Standards for Testing Welds

These Standard Tests Comprise

(a) Shop Standard: A simple standard test for such purposes as checking the work of a welder, testing a new lot of welding wire, and testing the effect of some change in conditions.

(b) Commercial Standard: For cases where more than one kind of test should be made but where the circumstances do not justify a complete investigation.

(c) Research Standard: When a complete investigation of a weld is to be made for research or other purposes, all tests and examinations are made which will contribute any information in regard to the characteristics of the weld.

Price per copy—Members 25 cents, Non-members, 50 cents.

BULLETIN No. II

Welding Wire Specifications and Folios

The specifications and folios are based on the data collected by the Welding Wire Specifications Committee as to the chemical analysis of welding wire used for both gas and electric welding in railroads, shipyards and other places and the service results obtained from the use of such wire.

Price per copy—Members 25 cents, Non-members 50 cents.

BULLETIN No. III

Standards for Electric Arc Welding Apparatus

These rules provide Standards for use in connection with specifications for the purchase, sale and use of Arc Welding Apparatus. The rules include classification, definition of terms, information relative to apparatus to be supplied by the manufacturer and by the prospective purchaser, respectively, and tests. Price per copy: Members 15c, Non-members 30c.

MEMBERS ATTENTION!

The Society desires to include in its Journal descriptions of different welding jobs. Enough details should be given in each case to enable the welder to duplicate the job. Illustrations and photographs are helpful.

Discussion of papers appearing in our Journal are particularly invited. Perhaps you do not agree with the author in certain deductions or contentions. Perhaps, also, you can supplement the information given from your own experience. Address all communications to,-

American Welding Society

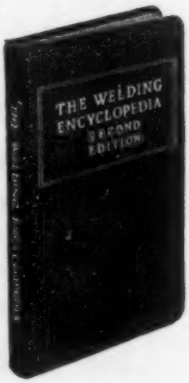
33 West 39th Street

New York City

NEW EDITION OF WELDING ENCYCLOPEDIA READY FOR DISTRIBUTION

The regular retail price of this book is $5.00. A special price of $3.00 has been made to the members of the American Welding Society if the order is placed through the office of this society. No reduction in price will be made on orders received directly from the subscriber.

The book this year will be bound in imitation flexible leather with gilt edges and contains about 100 additional pages. The new edition has been thoroughly revised and brought up to date.



Send order to

AMERICAN WELDING SOCIETY

33 West 39th Street, New York, N. Y.

Who's Who in Welding

The American Welding Society plans in the very near future to publish a printed directory of its members, including name, address, business connection and class of membership.

If you want your name associated with welding you cannot afford to be left out.

Write for an application blank

AMERICAN WELDING SOCIETY

33 West 39th Street, New York, N. Y.

Take the GUESS WORK Out of Welding

IN YOUR PLANT there is a man who needs timely and accurate information about welding. He should know what is being done in other plants to reduce costs and increase efficiency. No matter what your welding problem may be, The Welding Engineer is the best scource of information, the best adviser you could have. Every phase of welding, both manufacturing and repair problems, is discussed fully in this valuable monthly publication. The best authorities in America on the subject of welding are regular contributors.

Every process of welding is discussed by The Welding Engineer. Arc Welding, Electric Butt, Spot and Seam Welding, Oxy-Acetylene and the Thermit System, in fact every known process of joining metals is discussed. Its Buyers' Index reflects the progressiveness of America's first manufacturers.

L. B. MACKENZIE, Editor H. S. CARD, Associate Editor

Price $3.00 In The United States And Canada, $4.00 Abroad.

Write for free sample copy for convincing proof that The Welding Engineer is indispensable in your business.

Member Audit Bureau of Circulations

The Welding Engineer

608 S. DEARBORN STREET, CHICAGO

Member Associated Business Papers, Inc.

THE GAS WELDERS MONTHLY MAGAZINE

Acetylene Journal

Every day brings new information on the subject of gas welding. New uses for the torch, business-building kinks devised by shop proprietors and a hundred other things which help the welder.

Oxy-acetylene welding has its own publication in the ACETLYENE JOURNAL. All the news and developments of the day appear in its columns in the shape of helpful illustrated articles, news items and contributions by the "other fellow" which are helpful to you.

Several thousand welders read the Journal. Your name shou'd be on our list. Just send in your name, address and a one dollar bill ($1.00 per year in U. S. and Canada; $1.50 abroad) and you will insure a years interesting and profitable reading on YOUR trade.

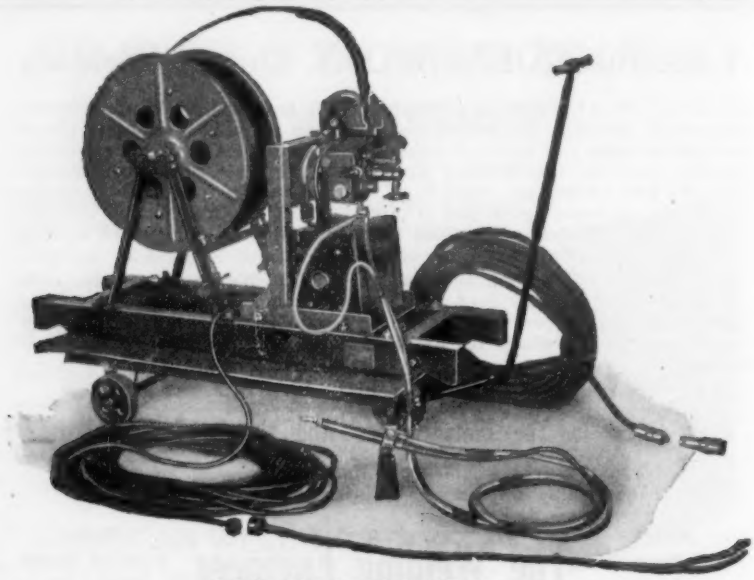
Write for a sample copy for convincing proof that the Journal is indispensable to your business.

H. W. COOK, EDITOR

ACETYLENE JOURNAL

122 So. MICHIGAN AVENUE CHICAGO, ILL.

All books on welding may also be obtained through this office, including the famous "Autogenous Welding" by Granjon & Rosemberg (price $3.00) for which this office has the exclusive American rights.



G-E Portable Semi-Automatic Arc Welding Equipment is the most advanced method of arc welding.

ACHIEVEMENT

From the first sets for hand welding operations to the new type of Portable Semi-Automatic Arc Welder—the General Electric Company has been a pioneer in the design and manufacture of equipment which gives to Industry the broadest uses of arc welding.

General Electric Company

General Office Schenectady, N.Y.

Sales Offices in all large cities 43B-651X

USUALLY CARBIDE MEANS UNION CARBIDE

It always does at 150 *Union Carbide warehouses,* strategically located from Portland, Maine, to San Diego, California, and from Seattle on Puget Sound to Tampa on the Gulf.

Union Carbide is always packed in blue-and-gray drums.

UNION CARBIDE SALES COMPANY
Carbide and Carbon Building—30 East 42nd St.
NEW YORK CITY

CHICAGO
Peoples Gas Bldg.

SAN FRANCISCO
Balfour Bldg.

Service That Carries On

LINDE is vitally interested in aiding oxygen users.

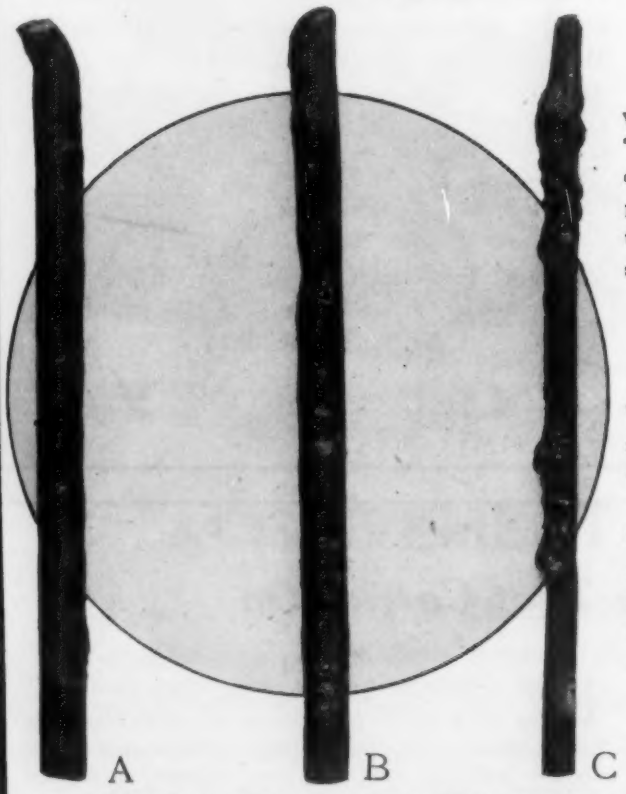
The *will to help* is futile if it is not combined with the *ability to serve.* In a nation-wide business such as the Oxygen Industry, ability to serve depends on physical facilities and organization.

84
Linde
Plants
and
Warehouses

Linde Service only *begins* with seeing that your oxygen supply requirements, wherever you may be, are satisfied promptly and fully. It carries on—extends real co-operation and constructive advice as to the efficient and economical use of oxygen. *It belongs to Linde users.*

THE LINDE AIR PRODUCTS COMPANY
Carbide and Carbon Bldg., 30 East 42nd St.
New York
Balfour Building, San Francisco.

What goes into the Weld?



Wires "B" and "C" show result of flame test applied to indicate the presence of slag and gases.

Wire "A" shows result of flame test applied to Page-Armco Welding Rods and Electrodes and indicates hte *absence* of slag and gases.

After the Welding Wire is deposited, the structure can be determined only by analysis, or the microscope, or a test to destruction. Remove one doubtful factor by using guaranteed Welding Metal.

Page-Armco Welding Rods and Electrodes are guaranteed 99.84% Pure Iron and conform in all respects to American Welding Society Specifications for Electrodes, E-No. 1-A, Specifications for Gas Welding Rods G-No. 1-A.

Page Steel and Wire Company

BRIDGEPORT, CONN.

District Sales Offices

Chicago New York Pittsburgh Portland, Ore. San Francisco

RWB DYNAMOTORS

MANY electric railways use RWB Dynamotors because of the advantages which they offer for rail bonding, rail joint welding, track repairs and shop welding. Send for our new catalogue and let us help you with your welding problems.

RAIL WELDING & BONDING CO.
CLEVELAND, OHIO

Acetylene in Portable Cylinders for Oxy-Acetylene Welding and Cutting

Supplied in any quantities. Do you understand our free loan plan? If not, we are glad to explain.

Supplied in the following sized cylinders.

10″ x 30″ size—capacity approx. 125 cu. ft.
12″ x 36″ size—capacity approx. 225 cu. ft.
12″ x 44″ size—capacity approx. 275 cu. ft.

Prompt and efficient service through plants and warehouses.

COMMERCIAL ACETYLENE SUPPLY CO., INC.
(Main Office) 80 BROADWAY, NEW YORK

BRANCHES:—
204 Trust Co. of Ga. Bldg., Atlanta, Ga.
540 So. Dearborn St., Chicago, Ill.
553 Monadnock Bldg., San Francisco, Cal.
18 Toronto St., Toronto, Ont., Canada.

"ALTERNAD"
CUTTING and WELDING

Machine that can be taken to the work. We will do immovable jobs anywhere in the world. Do you know any? Write for our plan to show you by actual performance.

Electric Arc Cutting and Welding Company
152-158 JELIFF AVENUE PHONES Waverly 7802-7803 NEWARK, N. J.

MILBURN
WELDING AND CUTTING APPARATUS
including all sizes of Welding and Cutting Torches, Regulators and Welding Generators is the development of 20 years' research

The result is a constant saving in gas consumption, time of operation and a higher efficiency

THE ALEXANDER MILBURN COMPANY
1420-1428 W. Baltimore Street Baltimore, Maryland

ROEBLING WELDING WIRE

For Electric Welding For Oxy-Acetylene Welding

Bare and Insulated Copper and Steel Wire and Wire Rope

JOHN A. ROEBLING'S SONS CO., TRENTON, N. J.

PHILADELPHIA—223-227 Arch St.
NEW YORK—117-119-121 Liberty Street.
BOSTON—93-95 Pearl Street.
CHICAGO—165 West Lake Street.
PITTSBURGH—Sandusky & Robinson Streets.
CLEVELAND—701 St. Clair Avenue, N. E.
ATLANTA—69 Walton Street.
SAN FRANCISCO—624-626 Folsom Street.
LOS ANGELES—216 S. Alameda Street.
PORTLAND, ORE.—487 Lovejoy Street.
SEATTLE—900 First Avenue, South.

Permanent Repairs of Heavy Broken Machinery

THERMIT WELDING

Shafts **Gears**
Crank Shafts **Rolls**
Crushers **Locomotive Frames**

Send for Pamphlet 1735.

METAL & THERMIT CORPORATION 120 BROADWAY NEW YORK
Boston Pittsburgh Chicago S. San Francisco Toronto

ELECTRIC ARC WELDING OUTFITS

Properly designed and built to give best service and satisfaction with the least possible attention

Self Contained—No Exciter Required.
Accurate Adjustment of Current.
Long Life Due to Moderate Speed.

Our Engineers Will Assist you in Determining What is Best for Your Needs.

We Invite Inquiries on All Matters Pertaining to Electric Arc Welding.

BURKE ELECTRIC CO.

Manufacturers of
ELECTRIC WELDING OUTFITS
and
ELECTRIC MOTORS AND GENERATORS FOR ALL PURPOSES.

Main Office and Works, Erie, Pa.

Service-Sales Offices

New York *Detroit* *Philadelphia*
Pittsburgh *Cleveland* *Buffalo*

AIRCO
DAVIS
APPARATUS

ANYTHING AND EVERYTHING

For Oxyacetylene Welding and Cutting

SERVICE

ECONOMY

The confidence born of association with good equipment is yours if you use Airco-Davis-Bournonville Pressure Regulators.

Write for Airco Booklet:
"Anything and Everything for Oxyacetylene Welding and Cutting"

AIR REDUCTION SALES COMPANY

Manufacturer of Airco and
Airco-Davis-Bournonville Products

Controls the manufacture and sale of National Carbide

Home Office: 342 Madison Ave., New York, N. Y.

Airco District Offices, Plants and Distributing Stations conveniently located throughout the Country.

"Airco Oxygen and Acetylene Service is Good Service"